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Texas Instruments, Inc., Dallas

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CENTRAL FLORIDA PHOSPHATE INDUSTRY AREAWIDE IMPACT ASSESSMENT PROGRAM

Volume VII: Alternative Effects Assesment

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Texas Instruments areawide assessment of the central Florida phosphate industry for the Environmental Protection Agency considered five scenarios conveying alternative themes and intents of possible policy decisions. To permit a decision as to which alternative presents the least regrettable effect, TI overlaid (figuratively), the present and projected environmental settings with these alternatives for industry regulation. In this volume (VII) of TI's 7-volume report to the EPA, the relationship of the scenarios and TI's assessment methodology is explained and a matrix displays the natural, social, and economic elements potentially impacted by phosphate industry activities and their level of impact. Effects determinations are discussed.

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Descriptors:

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Cultural geography	Land reclamation	Regional analysis
Demography	Land use	Regulations
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Environmental impact		

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FOREWORD

This is one in a series of reports presenting information developed by, or supplied to, Texas Instruments Incorporated (TI) while conducting an areawide environmental impact assessment of the central Florida phosphate industry for the Environmental Protection Agency (EPA). Because of the diversity and number of groups and individuals interested in this program, the EPA and TI encouraged active public involvement by making working papers available for review and comment as they were developed through environmental analysis, impact assessment, and alternative selection. These working papers then were prepared as a series of reports incorporating the original material modified through the incorporation of comments and additional information developed by TI. Other reports in the series include:

Volume	Title
I	Description of Program and Industry
II	Environmental Permits and Approvals Relating to Phosphate Mining and Fertilizer Manufacturing in Florida
III	Socioeconomics
IV	Atmosphere
V	Water
VI	Land

These reports are made available through the National Technical Information Service to serve as background information to the environmental statements (draft and final) and environmental planning needs of federal, state and local agencies as well as other interested parties. The information will be of value to those involved with development and regulation of the phosphate industries, others who plan developments in central Florida, and environmental planners in general who must deal with environmental issues on a regional basis. It is hoped their use will lead to good decisions. It has often been said that decisions are only as good as the information on which they are based. Extending that philosophy, decisions are only as good as the decision makers' understanding of the adequacy of the information in resolving the issues being examined.

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SECTION 1

INTRODUCTION

A. PUBLIC POLICY SCENARIOS

To isolate relevant information to aid in the decision-making, descriptions of various alternatives proposed as the basis for assessing the effects of the central Florida phosphate industry were an important consideration. The first description was in the form of a scenario that conveyed the intent of that alternative. (Scenario is a synopsis of a play; in terms of policy decisions, it conveys a theme and intent of administrative action.) Each scenario then was described in terms operational for the assessment of environmental effects.

In this section each scenario is described in terms that convey the issues of potential effects, thus giving direction to the assessment of effects (discussed in Chapter 2) and the assessment methodology (described in Section 2 of this chapter). To assess effects and determine impacts, the environmental setting - present and projected through the year 2000 - was figuratively overlaid with alternatives for environmental regulation of the phosphate industry. A decision had to be made as to which alternative presents the least regrettable effect on the environment.

The scenarios in the contract between the Environmental Protection Agency (EPA) and Texas Instruments Incorporated (TI) were the result of interagency review of the issues involved, as perceived by interested private parties, industry, and federal, state, and local governments. Additionally, EPA solicited comments by newsletter. The form of the following scenarios represents revisions subsequent to that effort:

2.11 The development of the phosphate mining and processing industry associated with the issuance of National Pollution Discharge Elimination System (NPDES) (Section 402) and Section 404 of PL 92-500 permits to existing and new source phosphate facilities, all of which would meet effluent and receiving water standards applicable as of the date of the contractor's proposal to EPA; Florida Department of Environmental Regulations (DER) and EPA permits to air sources meeting requirements of the Clean Air Act, including but not limited to nonsignificant deterioration requirements, standards of performance for new stationary sources; and other local, state, and federal permits applicable as of this date of the contractor's proposal to EPA. Current reclamation requirements are also to be included.

2.12 Process Modifications for New Sources

1) Elimination of slime ponds
2) Chemical processing of wet rock (eliminate drying process)
3) Dry conveyor for matrix from mine to beneficiation
4) Recovery of fluoride from recirculated process water, including scrubber water
5) Uranium recovery from all phosphoric acid
6) Impervious lining for recirculated process water ponds at chemical plants

2.13 Reduced Water Usages

A) Existing Facilities

1) Chemical Processing (including elemental phosphorus and animal feed ingredient plants). Complete recirculation of all cooling and process water. Design for containment of cooling and process water for up to 10-year, 24-hour maximum rainfall event to meet BPT effluent limitations.

2) Mining and Beneficiation
Complete recirculation of all water, except surface runoff from undisturbed areas. Design for containment of 10-year, 24-hour rainfall event.

B) New Facilities

1) Chemical Processing (including elemental phosphorus and animal feed ingredient plants). Complete recirculation of all cooling and process water. Design for containment of cooling and process water for up to 25-year, 24-hour maximum rainfall event. Discharges as a result of rainfall exceeding the equivalent of a 25-year, 24-hour rainfall event to meet Standards of Performance for New Sources.

2) Mining and Beneficiation
Complete recirculation of all water, except surface runoff from undisturbed areas. Design for containment of 25-year, 24-hour rainfall event.

2.14 A) No mining or development of facilities for processing (beneficiation or chemical processing) in either waters of the United States or wetlands as defined by EPA and the Corps of Engineers in regulations promulgated pursuant to the Federal Water Pollution Control Act, as amended, Section 404.

B) Any disturbed wetlands are to be restored to provide at least an equivalent habitat for any species on the Important Species List for which habitat existed prior to mining. Restoration is to be accomplished so that no more than 10 percent of such habitat is destroyed at any one time.

2.15 No development of phosphate mining and processing beyond that associated with the issuances of section 402 and 404 permits for existing sources, all of which would meet effluent and receiving water standards applicable as of the date of the contractor's proposal to EPA; Florida DER and EPA permits to air sources meeting requirements of the Clean Air Act and regulations promulgated pursuant to the Act, including but not limited to nonsignificant deterioration requirements; standards of performance for new stationary sources; and other appropriate local, state, and federal permits applicable as of the date of the contractor's proposal to EPA. This scenario constitutes the "no-action" alternative as required by the NEPA.

B. PRESENTATION OF SCENARIOS FOR ENVIRONMENTAL ASSESSMENT

From the contractual language, TI, with information provided by the EPA, private industry, and various federal, state, and local agencies and assisted by the engineering firm of Tomasino and Associates, translated the scenarios into the descriptions found herein.

The scenarios range from no further permitting of effluent or air discharges beyond those sources existing as of August 1, 1976, to the permitting of all applicants pending review as of August 1, 1976. Between these extremes and serving as considerations with them are scenarios related to water conservation, technological process modifications, and development in waters of the U.S. and wetlands.

These scenarios and the results of assessment of their effects are described in the following order:

- Issuance of existing source permits only
- Issuance of existing and new source permits
- Process modifications for new sources
- Reduced water usages
- Waters of the U.S. and wetlands

Some basic facts and projections are presented in Figures 1.1 through 1.8 and Tables 1.1 through 1.7, while Plate 1 (in map pocket) shows the relationship of existing and projected phosphate industry activities to the waters of the U.S. and wetlands and Plate 2 (also in map pocket) shows projected activities relative to present land use. The reader will see these tables and figures referred to again as they pertain to each scenario. Because of the divergence of U.S. Bureau of Mines and phosphate industry production and reserve estimates, data showing a modified version of Scenario 2.11 (2.11') are displayed. These data were not used for effects assessment per se but were used to evaluate how some results might be qualified if 2.11' became reality.

C. ASSESSMENT METHODOLOGY

1. General

Environmental effects assessment is a process through which environmental impacts of proposed policy or developmental projects are revealed, analyzed and evaluated. Assessments may be undocumented or documented and are the result of considerable effort by a variety of expert advisors or the result of decision-makers' cognitive processes alone. The most effective assessment process is one which is an early and integral part of the policy or project planning and design. Policies or projects that internalize social, economic, and natural environmental considerations to the planning and design of actions which could impact our environment are more likely to be compatible with and less adversely impactful to the environment than those that consider administrative, techological, or economic feasibility alone.

The methodology of assessment is important to the decision-maker: inadequacy might result in a less-than-thorough and comprehensive consideration of all pertinent issues or mask the significance of those issues. The best methodology is one which applies interdisciplinary knowledge and systems concepts.

The effects assessment methodology used by Texas Instruments Incorporated (TI) on the Central Florida Phosphate Industry Areawide Impact Assessment Program consisted of a rational, methodical series of events within a system's (holistic) point of view performed by a highly interactive interdisciplinary team of experts. These events are outlined in Figure 1.9 and are described in more detail in Figure 1.10. The methodology was sufficiently flexible to accommodate specific regulatory agency guidelines and sufficiently institutionalized to assure effective results.

2. Display of Effects

The purpose of environmental effects assessment is to advise decision-makers and give them information that will lead to good decisions. The effective display of that information is central to the assessment's effectiveness. The final display, however, need not contain detailed technical data; in fact, an overabundance of detail hinders good decision-making. In other words, each person involved in planning, designing, assessing, and decision-making requires his or her own level of detail in the analysis and display of results. For this reason, the effects are best displayed in hierarchal layers of detail dovetailing into an increasingly expanding base of information and data, each level serving a purpose subordinate to but consistent with the major objectives of the assessment program.

Environmental effects assessment involves a variety of complex issues, and checklists are an effective way of accounting for those issues. First, an exhaustive "laundry list" comprising the sum of all pertinent factors to be considered by each discipline for the generic action to be assessed is made. This involves someone with not only expertise in an environmental discipline but an informed awareness of the activities implied by a given policy or project. The literature is replete with such checklists, and they have their place in the decision-making process.

More directly applicable to effects assessment of a defined program is the checklist that accounts for environmental elements probably impacted by the action being addressed. This list is a subset of the "laundry list."

Finally, a list of elements (environmental versus program [technological or policy] activities) that reveal to the decision-maker the most significant issues to be addressed and most probably impacted by the set of specific feasible alternatives becomes the source for titles of the elements in the environmental effects (EE) matrix. The program activities (Y axis) are reduced in detail only to the level at which a discernible and separable causative action could result in a significant impact attributable to that action. The elements for the central Florida phosphate industry effects matrix were selected through:

- Inputs from the contractual work statement (the decision indicators)
- A survey of public media
- Comments from steering and advisory committee members or individuals of the groups they represented
- A survey of technical literature
- Staff a priori knowledge of the disciplines or issues involved

The final draft of the matrix (Plate 3 in pocket) displayed activities of the central Florida phosphate industry and the natural, social, and economic environmental elements potentially impacted by one or more of the industry activities. Each scenario was described and the effects displayed in terms of assessment of significance; thus, one completed matrix exists for each scenario. A given column or row may be inapplicable to a given scenario, or it may contain all zeros, indicating no significant effect. Among the set of alternatives, however, each industry activity and each environmental element are addressed.

The comparison display matrix replaces industry activities with the title of each alternative, and entries under each environmental element consist of algebraic sums under each column for the given alternative. The matrix prepared for the central Florida phosphate industry (Plate 3 in pocket) was used to:

- Display causative factors from the alternatives, as well as beneficial and adverse significant effects
- Inventory environmental elements (i.e., entities, properties, or processes affecting man directly or through his relationship to his natural, societal, or economic environment) to give technical direction to the staff and assure thoroughness
- Reveal interactions among the elements within each group (i.e., alternative versus environmental elements)

The matrix was used also to formulate plans for avoiding, minimizing, or mitigating adverse effects and enhancing beneficial effects. The display included interacting elements and the nature and effect of their interaction. When alternative plans were modified, effects were modified and each matrix for the appropriate alternatives summarized to the limit of quantification to reflect the overall stature of each alternative with respect to the environmental elements.

Elements for inclusion in an environmental effects (EE) matrix are determined based on a priori information, scenarios describing alternatives, laws and regulations, input from affected governmental and private groups, and guidance from the decision-makers. For this program, elements listed under "alternative demand elements" represented causative factors; the listed environmental elements were based on government guidelines, implementing instructions, a priori knowledge, and investigative results as appropriate to the planning area and represented the decision indicators established by the decision-makers, with recommendations from TI. The hierarchal concept applies to checklists and to a 2-dimensional array (called a matrix) of checklists. The hierarchal concept for using checklists, matrices, and overlays involves reasoned judgment at each level of detail. Because of this, it was important that a common philosophy of approach be adopted on the program and that well-documented rationale and information support each summary and final assignment of judgment. In this way, the next level of judgment, then decision-making (and finally the public), has the option and opportunity to understand to the fullest the information and conclusions from which the decision emanated.

An environmental element entitled "habitat quality" was the appropriate level of detail for a decision-maker. For the ecologist advising the decision-maker, two or three displays representing increasing levels of detail of effects were required. Using the example given, habitat quality included assessment of physical and biological variables at a population and community level and in immediately affected and total-range areas. Thus, two or three conceptual overlays were used to arrive at a habitat type for a given species, a combination of that composite was conceptually overlayed with other composites to display habitats by community, and another level was used to show a total effect for all

communities affected by a given action. The field or laboratory technician had a checklist and a 2-dimensional array of interacting factors, which were then summarized to checklists and matrices for senior scientists, who then summarized these into the total effects assessment matrix for the decision-makers.

The first matrix entries were (-), (+), or (0), giving some direction to information needs and acquisition activities to satisfy those needs. Next came an individual staff member's conclusion as to the magnitude of effect for areas within his or her responsibility; again, this process gave direction to effective employment of expertise and use of time. The final designation of effect resulted from the effects assessment workshop. For each significant effect, a supporting rationale was cross-indexed to the matrix through use of the X, Y coordinate system. If mitigative measures modified effects, the modifications were revealed in the supporting rationale, which thus revealed the dependency of the final effects designation on the probability of success of a mitigative measure.

The summation of effects required an understanding of interactive components of the environmental systems being impacted. If a given causative action resulted in effects via pathways having differential magnitudes or signs (-) for adverse, (+) for beneficial for each component (environmental element or industry activity), the net effect had to be held in account. The interactive interdisciplinary team, operating within a systems conceptual approach, helped reveal the occasions when this phenomenon was germane and assured dedication to concept integrity. A good example is where community development is adversely affected by land excavation but beneficially affected by reclamation. The net benefit of lands for community development resulting from phosphate industry land-management practices, however, may not be the same net benefit resulting from lands unexcavated. Thus, a simple conceptual component model relates this phenomenon quite well, revealing a net "system output" that maintains the integrity of the methodological approach of algebraically summing effects for alternative comparisons.

D. INTERDISCIPLINARY TEAM ANALYSIS AND ASSESSMENT

The variety of information needed to assess the effects of a given action is determined by the variety of issues and the complexity of the proposed action; in turn, the disciplines required can be so varied and complex that no single individual can adequately address either the breadth or depth of the information needed for analysis and assessment. Figure 1.11 indicates just a few general disciplines for environmental analyses that require both generalists and specialists operating as an interdisciplinary team. The number of specialists or skills varv among assessment programs, but the generalists, without exception, must be knowledgeable in all of the items listed for analysis. For the planning phase, the generalist must be skilled also in assessment methodologies and the techniques for describing and displaying effects and establishing communications among team members.

The interdisciplinary team approach was effectively employed on the central Florida phosphate industry areawide impact assessment program. By first focusing on environmental systems, then components, and finally attributes of those components, the team systematically developed an expanding awareness and knowledge of potential effects and their causative factors. Throughout the analysis and planning phases of effects assessment, information flow was the key operational function monitored. As various team members interacted in a systematic way there was developed a documented information base that afforded an awareness, appreciation, and understanding of the issues involved and how they were interrelated among the scientific disciplines.

Several disciplines were needed in assessing the regional effects of the central Florida phosphate industry. The team assembled included personnel with expertise in regional analysis, land use, demography, economic activity projections, water resource engineering, geohydrology, geology, radioecology, geochemistry, physical chemistry, chemical engineering, environmental chemistry, air quality, aquatic and terrestrial ecology, cartography, remote sensing, modeling, systems analysis, program management, information retrieval and management, technical writing and editing, and effects assessment methodology. Key staff members met weekly to discuss progressive stages of the program, to assure interchange of information, and to identify plans and establish action for the satisfaction of information needs; as the environmental analysis phase

matured, the focus of these meetings shifted toward the environmental planning activities of scenario description and effects assessment.

Three workshops covered the design of baseline information acquisition activities, the information needs and interdependencies of the disciplines, the refinement of the total effects matrix, and the methodological approach - and consultants familiar with the local and regional issues and with specific disciplines as they pertain to the central Florida phosphate industry complemented TI staff expertise at these workshops. In addition, a series of ad hoc working meetings were held by staff members whose areas of responsibility included highly interactive components. Various staff members made various presentations on specific topics that required in-depth analysis or orientation to unfamiliar topics. Major activities of the program were described in a series of working papers documenting the information base and instructing and informing staff members and persons outside of TI.

The culmination of these interactions was an intensive effects assessment workshop where the matrix was used to guide all staff members through a series of "friendly adversary" proceedings to reveal rationale supporting effects determinations. By having the whole team participate in this proceeding, specialized areas were addressed to the depth required and the accountability of "pass through" or secondary effects was assured. Also decided were the forms of displays of specific effects and the proper supporting documentation. Each staff member presented the assessment of effects as he or she determined from analysis of information in his or her disciplines and, in turn, offered comments on the rationale presented by others. The program manager arbitrated extreme differences in conclusions or was responsible for advising and seeking direction from the EPA project officer in cases in which issues dealt with value judgments or policy-making. The final objective was to present a thorough, well-documented effects assessment rationale for each determination of a significant effect. This would assure the reader that conclusions were appropriate to the information available for analysis and would disclose the decision-making or thought processes operational for each issue addressed.

E. PARTICIPATION OF FEDERAL, STATE, AND LOCAL GOVERNMENTAL AGENCIES AND INTERESTED PARTIES

Since the successful completion of a program addressing broadly defined regional issues affects policy-makers and private citizens at several levels of authority or interest, two formal structures and informal procedures were used on the central Florida areawide impact assessment program to assure productive, participatory involvement and interagency coordination:

- Federal activities and interest were addressed by the formation of a steering committee composed of representatives of the EPA, USDI (Bureau of Mines, USGS, and Fish and Wildlife Service), the U.S. Army Corps of Engineers, and the state of Florida through its representative, the Secretary of the Florida Department of Environmental Regulation, and chaired by a representative of the President's Council on Environmental Quality. (The chair was assumed by the EPA when administration of the Federal EIS program was shifted from CEQ to EPA.)

- Local government and interested parties were represented on an advisory committee. Representatives of the phosphate industry, each of the seven counties comprising the study area, the water management districts, and environmental interest groups reviewed working papers and served as focal points for coordination of information acquisition. The EPA, via a monthly newsletter, kept the members of these committees informed, and presentations were made at committee meetings by the EPA and TI.

Informally, TI participated in information acquisition and preliminary review activities with all federal, state, and local agencies supplying information. By means of this process, the information base was as comprehensive and as thorough as could be obtained within the time and budget constraints.

The EPA also held public meetings and made all working papers available for general public review through county offices and libraries. Comments were solicited from all reviewers and were addressed on a real-time basis during the progress of the program.

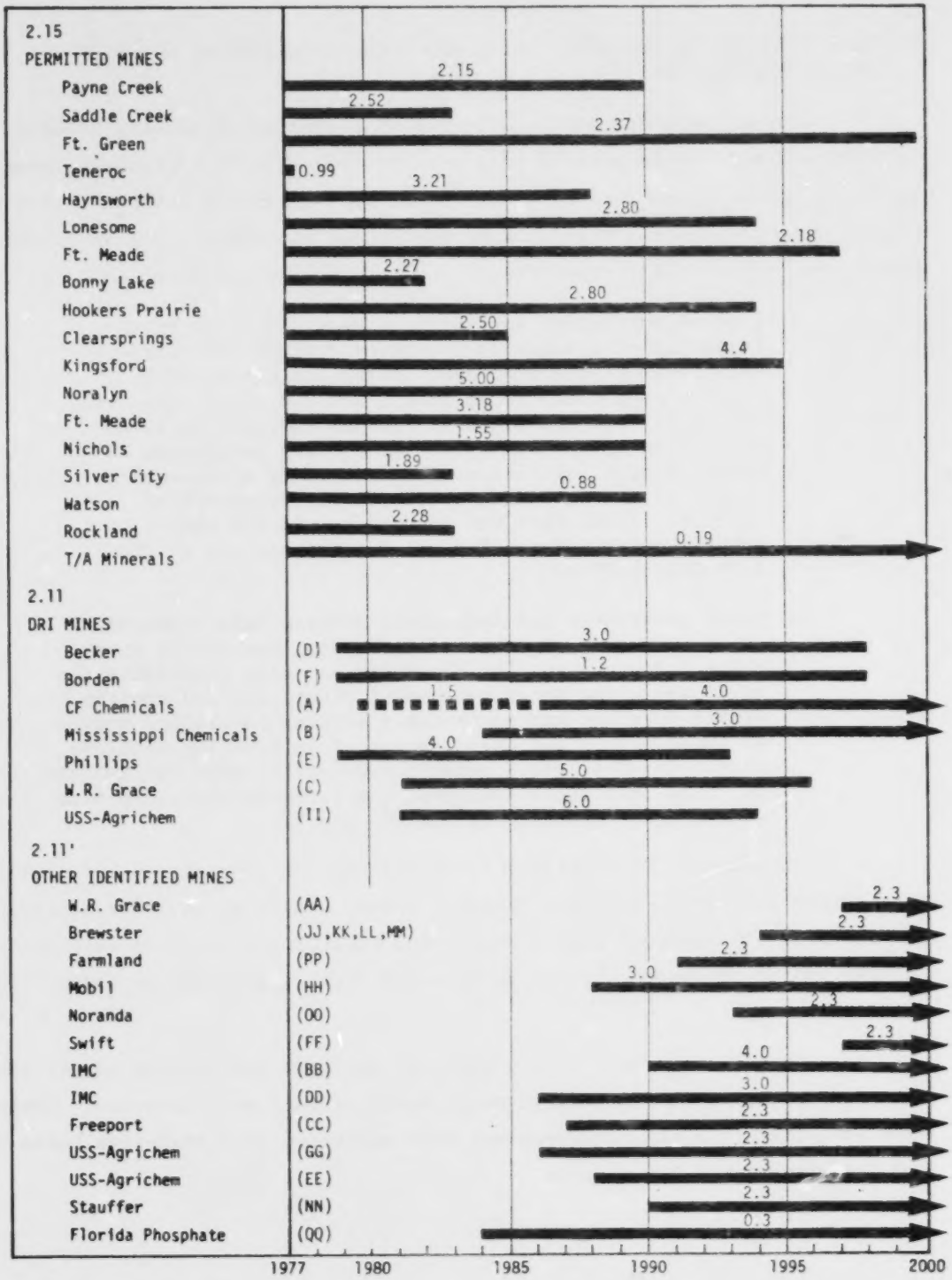


Figure 1.1. Projected Life and Production Rates ($X10^6$ tons/year) for Central Florida Phosphate Mines. (Capital letters in parentheses refer to Plate 1.)

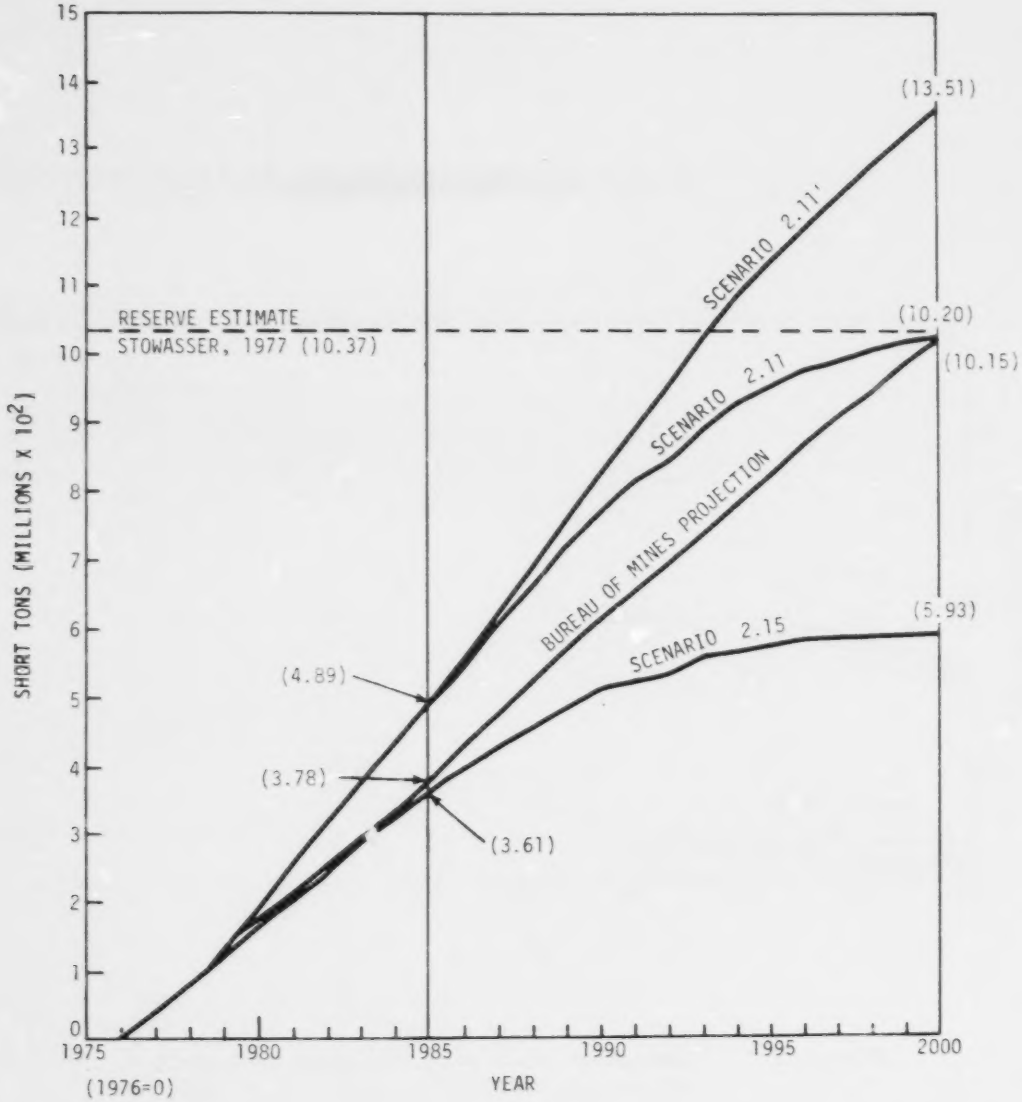


Figure 1.2. Cumulative Projected Production Estimates for Central Florida Phosphate Industry

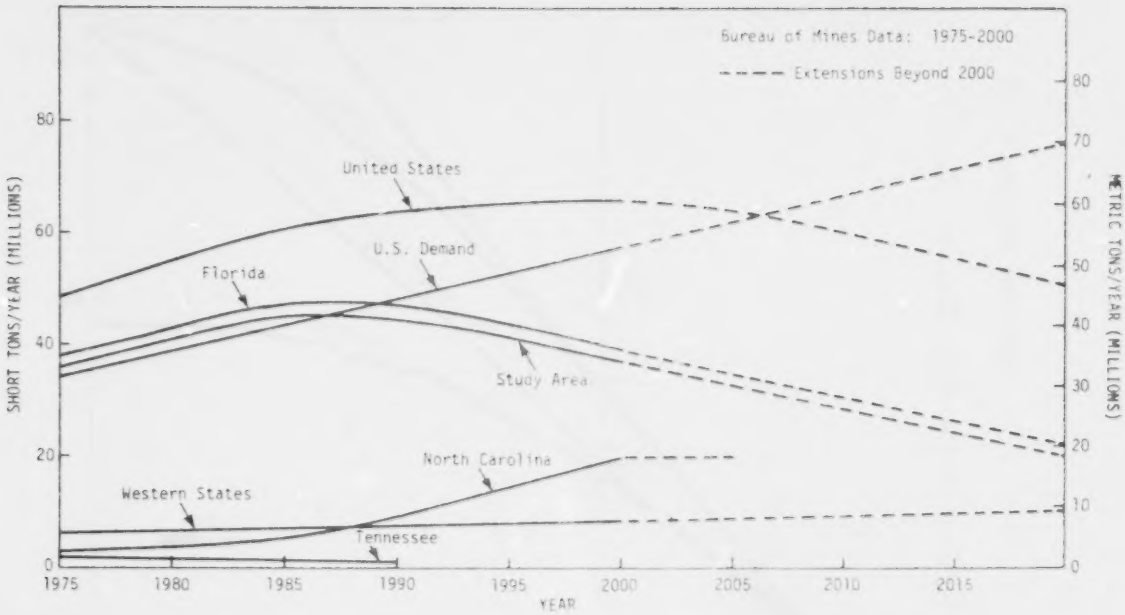


Figure 1.3. Phosphate Rock Supply-Demand Projections (Stowasser 1977a)

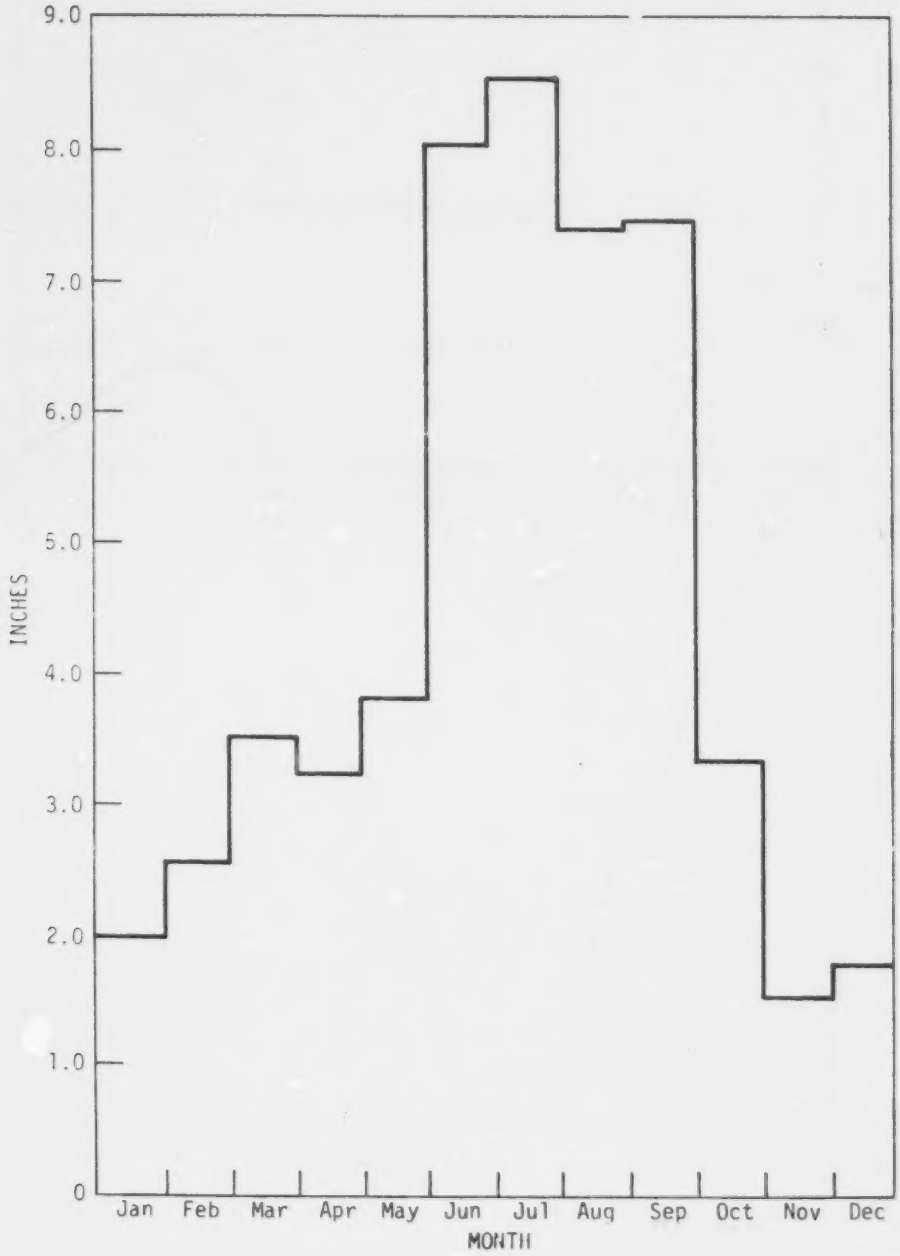


Figure 1.4. Average Monthly Rainfall at Six Locations in Study Area

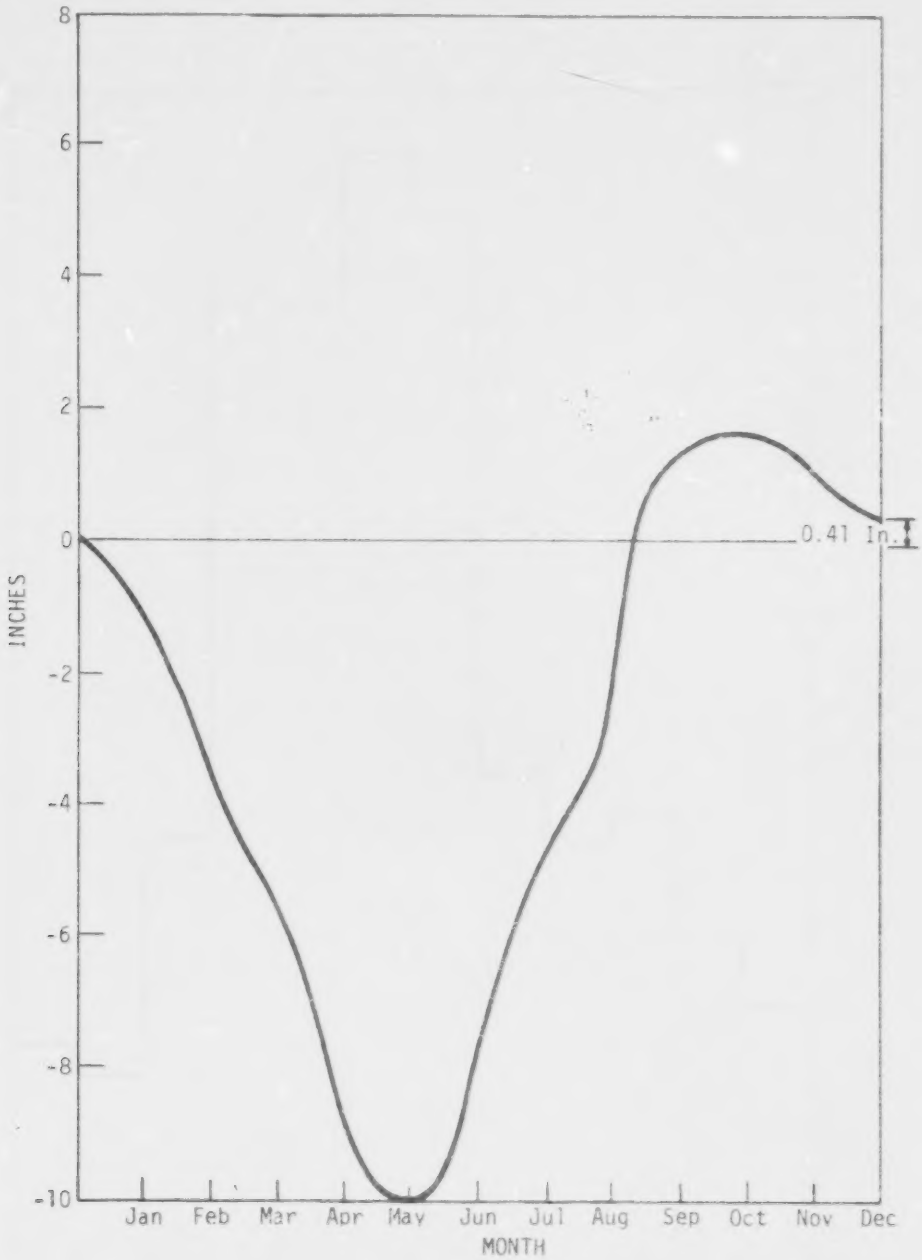


Figure 1.5. Curve of Cumulative Rainfall Vs Evaporation, Average Year in Study Area

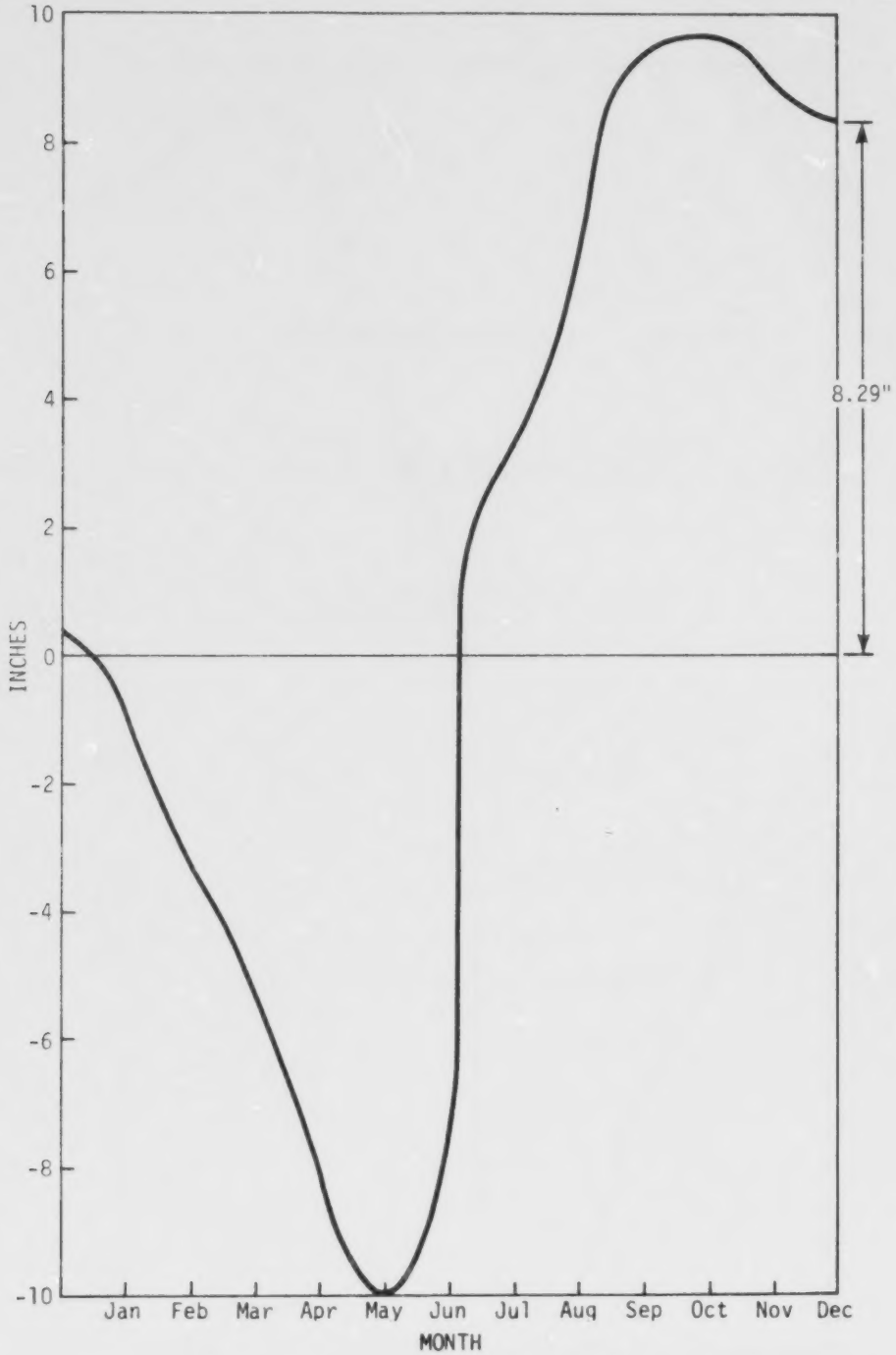


Figure 1.6. Curve of Cumulative Rainfall Vs Evaporation, Year with 10-Year/24-Hour Storm

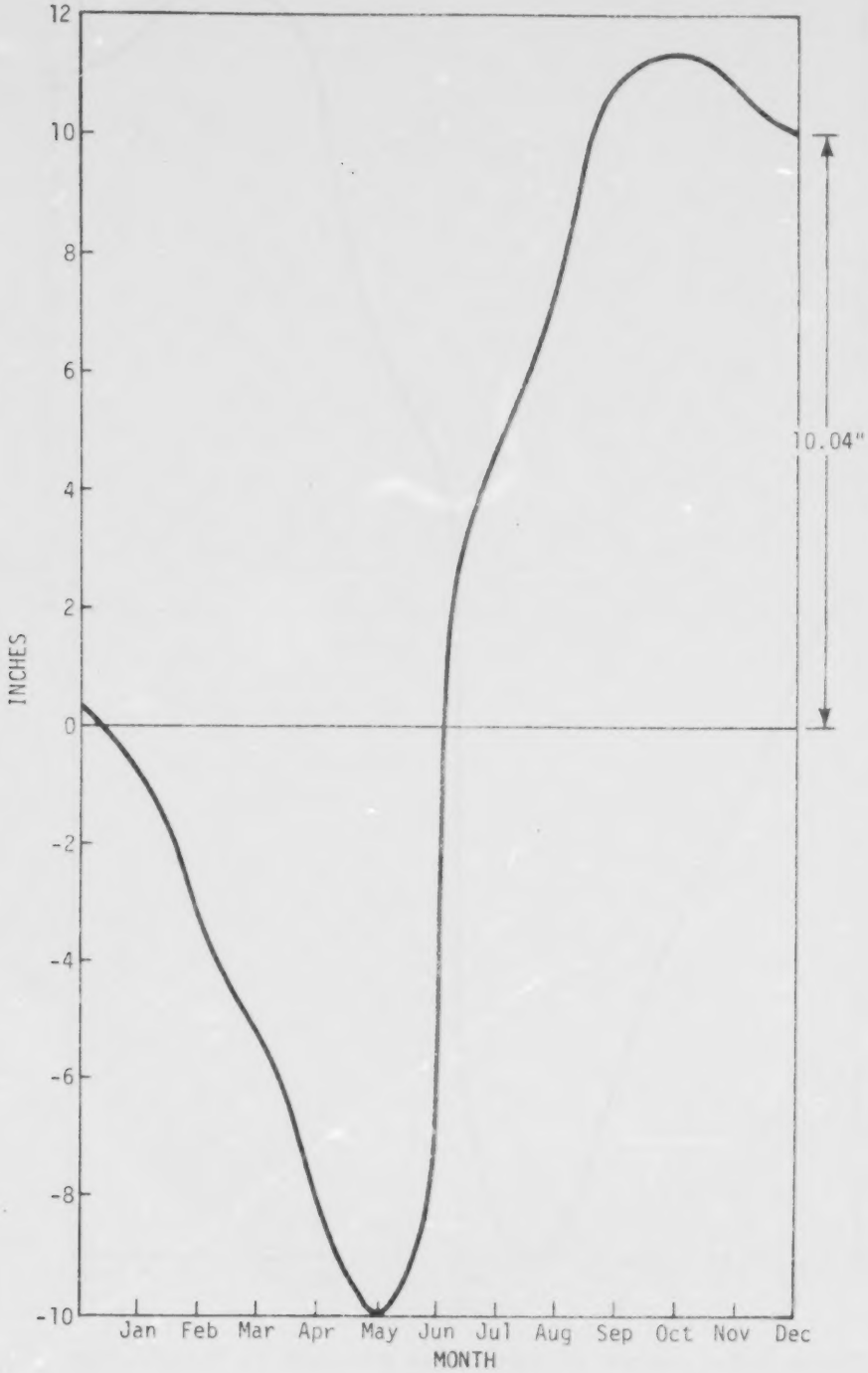


Figure 1.7. Curve of Cumulative Rainfall Vs Evaporation, Year with 25-Year/24-Hour Storm

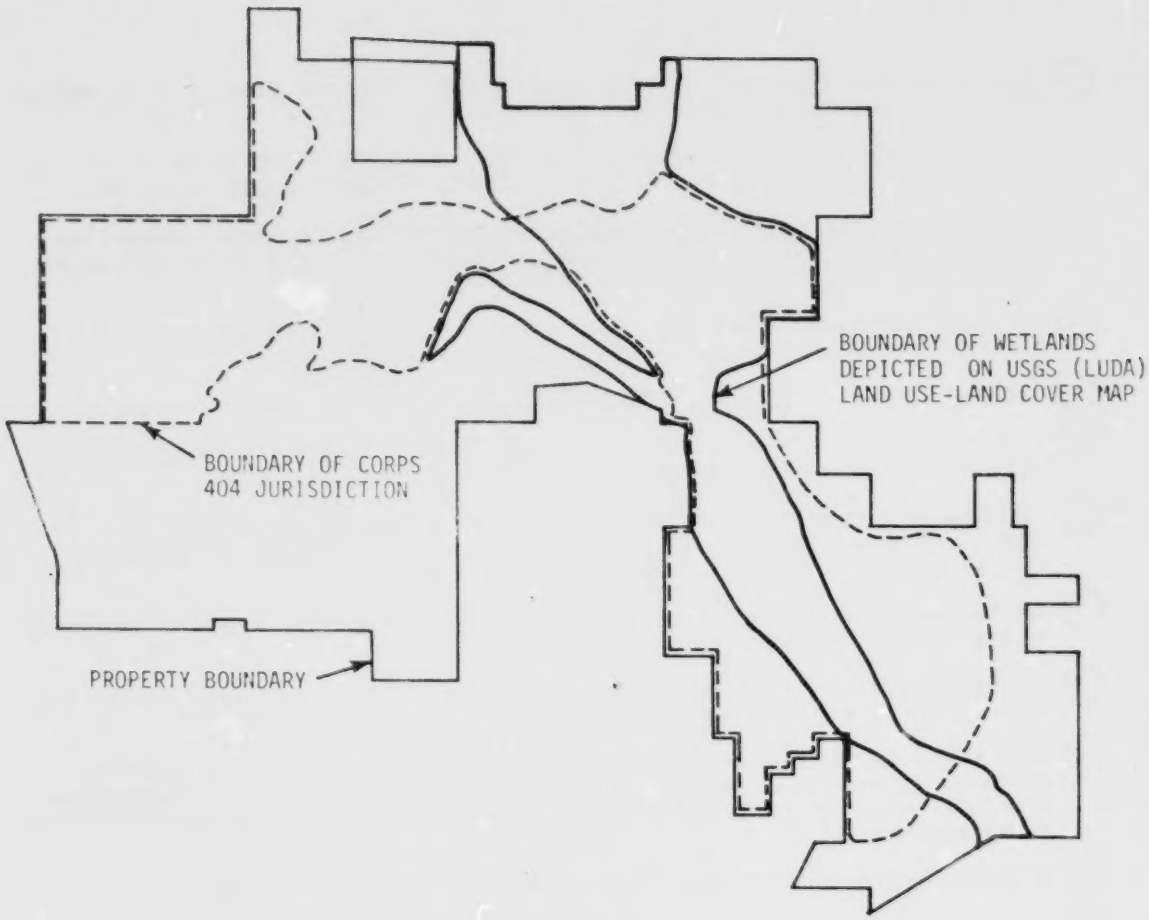
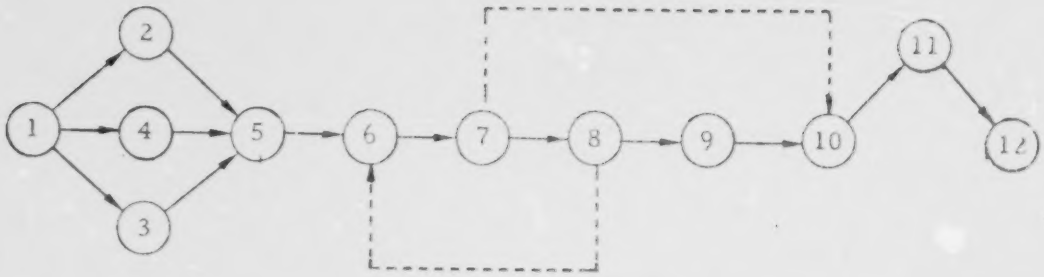


Figure 1.8. U.S. Corps of Engineers Boundary of Jurisdiction under Section 404 of FWPCA for W.R. Grace Hookers Prairie Mine



1. Profile the planning area by describing the present state and dynamics of the natural, social, and economic environmental systems.
2. Extend the profile to the planning horizon, describing the environmental systems as they would exist, while maintaining the status quo ("without action" alternative).
3. Determine alternatives to the proposed action, identifying causative factors (technological demand elements), and trace the pathways of their effects for each alternative, thus forming the Y axis of the effects matrix.
4. Determine the environmental demand elements potentially impacted and significant to the decision-makers, thus forming the X axis of the effects matrix.
5. Identify significant effects and assign a (-) or (+) to the interactive element.
6. Describe and display each significant effect, quantify the effect as appropriate, and assign to it a value representative of its level of significance.
7. Formulate effects matrices for each alternative and document the rationale for determining each effect, using the X, Y coordinates to cross-index the documentation to the matrices. (This could provide lead time to Step 10.)
8. Consider measures that may avoid, mitigate, or minimize adverse or enhance beneficial effects. (This may justify return to Step 6.)
9. Document the effects assessment results and disclose them to interested parties and federal, state, and local governmental agencies.
10. Incorporate the information emanating from Step 9, compare alternatives, and formulate an action plan to implement the preferred alternative (i.e., the alternative with least-regret/greatest-environmental benefit or the alternative least detrimental to the environment).
11. Determine whether an Environmental Impact Statement (EIS) is required.
12. If an EIS is required, prepare the draft statement for submission.

Figure 1.9. Network Diagram of Procedures for Preparing Environmental Assessment and Impact Statements

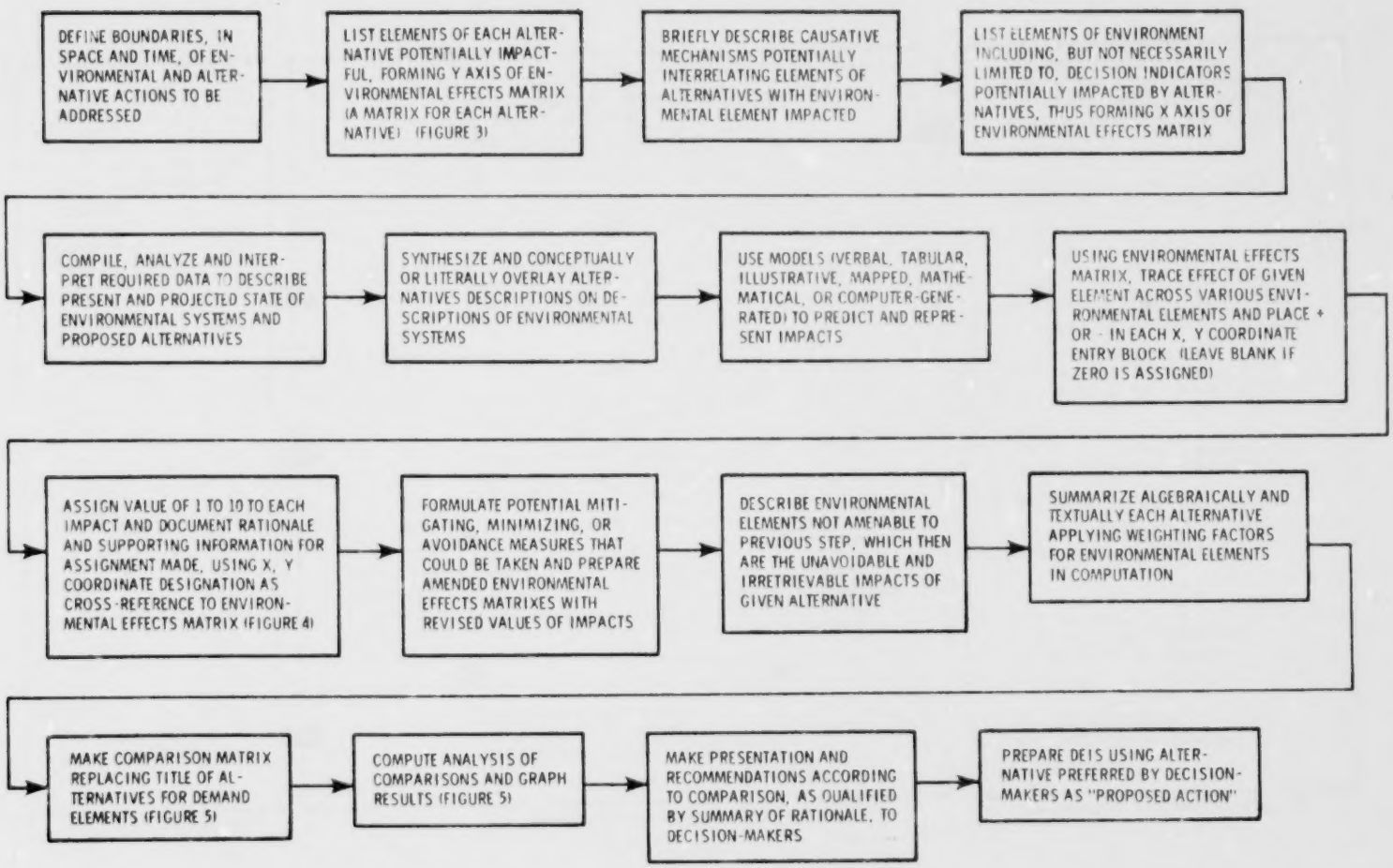


Figure 1.10. Flowchart of Methodology for Environmental Impact Assessment

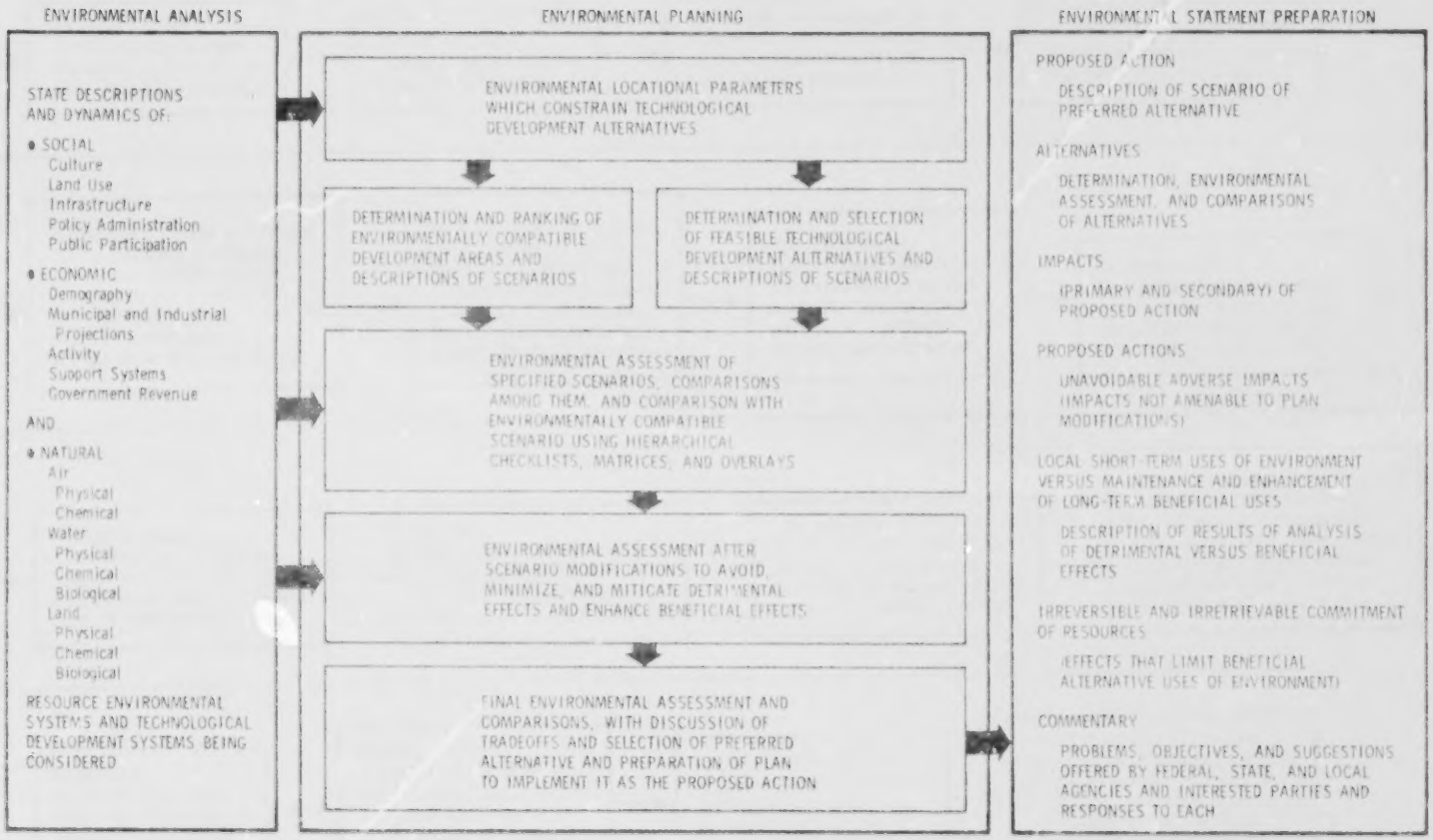


Figure 1.11. Interrelationships of Environmental Analysis, Planning, and Statement Preparation

Table 1.1. Assessment of World Phosphate Reserves and Resources*

	Millions of Metric (Short) Tons					
	Reserves†		Other Resources		Total Resources	
North America						
U.S.	2,268	(2,500)	4,082	(4,500)	6,349	(7,000)
Other	< 2	(2)	< 2	(2)	4	(4)
Total	2,269	(2,502)	4,083	(4,502)	6,352	(7,004)
South America	73	(80)	381	(420)	454	(500)
Europe						
USSR	726	(800)	2,902	(3,200)	3,628	(4,000)
Other	27	(30)	64	(70)	91	(100)
Total	753	(830)	2,966	(3,270)	3,719	(4,100)
Africa						
Algeria	100	(110)	36	(40)	136	(150)
Egypt	181	(200)	181	(200)	363	(400)
Morocco	9,070	(10,000)‡	45,350	(50,000)	54,420	(60,000)
Senegal	118	(130)	64	(70)	181	(200)
South Africa	91	(100)	45	(50)	136	(150)
Spanish Sahara	1,542	(1,700)	1,814	(2,000)	3,356	(3,700)
Tunisia	454	(500)	1,361	(1,500)	1,814	(2,000)
Other	91	(100)	91	(100)	181	(200)
Total	11,646	(12,840)	48,942	(53,960)	51,518	(66,800)
Asia						
China	54	(60)	NA	(NA)	NA	(NA)
Israel	36	(40)	NA	(NA)	NA	(NA)
Jordan	91	(100)	NA	(NA)	NA	(NA)
North Vietnam	64	(70)	NA	(NA)	NA	(NA)
Syria	454	(500)	NA	(NA)	NA	(NA)
Other	18	(20)	NA	(NA)	NA	(NA)
Total	308	(340)	1,814	(2,000)	2,122	(2,340)
Oceania						
Australia	907	(1,000)	1,814	(2,000)	2,721	(3,000)
Pacific Islands	108	(120)	27	(30)	136	(150)
Total	1,016	(1,120)	1,841	(2,030)	2,857	(3,150)
World Total	16,065	(17,712)	54,585	(60,182)	76,092	(83,894)

NA = not available.

†Estimated recoverable reserves at $27.66 per short ton published by Phosphate Rock Export Association 70 BPL price f.o.b. Florida plant, effective July 1, 1974, and competitively marketed at this selling price.

‡Minimum; reserve may be as large as 40 billion tons.

*Stowasser(1975)

Table 1.2. Estimated Phosphate Rock Reserves and Resources in 7-County Study Area*

County	Recoverable Phosphate Rock			
	Measured Reserves [metric (short) tons in millions]		Measured Sub-economic Resources [metric (short) tons in millions]	
Polk	402.7	(444)	95.2	(105)
Hillsborough	181.4	(200)	13.6	(15)
Manatee	164.2	(181)	149.7	(165)
Hardee	176.0	(194)	299.3	(330)
DeSoto	16.3	(18)	63.5	(70)
Sarasota				
Charlotte				
Total	940.6	(1,037)	621.3	(685)

*Stowasser 1977b.

Table 1.3. Estimated Phosphate Industry Water Demands on Floridan Aquifer, 1976-2000*

	Million Gallons per Day (mgd)								
	Chemical Plants			Mining/Beneficiation			Totals		
Scenario	1976	1985	2000	1976	1985	2000	1976	1985	2000
2.15	93.04	94.49	94.49	259.27	260.72	101.28	352.31	355.21	195.77
2.11	Same	Same	Same	Same	304.05	124.11	352.31	398.54	218.6
2.11'	Same	Same	Same	Same	310.84	257.29	352.31	405.33	351.78

*Deviations described in Volume V, Section 1, of working papers (TI 1977)

Table 1.4. Summary of Projected Acreage Estimates, Central Florida Phosphate Industry

	Hectares/Acres (thousands)					
	Mined		Reclaimed*		Reclaimed 2.12(1)*	
Scenario	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	19.9/49.1	32.6/80.6	19.6/48.4	39.2/96.8	22.5/55.5	40.1/99.1
2.11	27/66.7	56.3/139.1	23.7/58.5	60.3/148.9	27.7/68.5	63.1/155.8
2.11'	27/66.7	74.3/183.7	23.7/58.5	72.3/178.6	27.7/68.5	78.8/194.8

*Includes carryover acreage in slime ponds from years prior to 1977.

Table 1.5. Summary of Projected Estimates of Mining and Reclamation Acreage by River Basin

		Hectares/Acres (thousands)						
		Mined		Reclaimed		Reclaimed to Lakes		
Scenario	River Basin	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000	
2.15	Hillsborough	-	-	-	-	-	-	Existing Mines
	Peace (east)	14.1/34.9	19.5/48.3	13.9/34.4	25.4/62.8	5.2/12.9	7.2/17.9	
	Peace (west)	-	-	-	-	-	-	
	Little Manatee	.12/0.3	1.4/3.5	.12/0.3	1.7/4.2	.04/0.1	.53/1.3	
	Manatee	-	-	-	-	-	-	
	Alafia	5.8/14.4	10.0/24.8	5.5/13.7	12.1/29.8	2.1/5.3	3.7/9.2	
	Myakka	-	-	-	-	-	-	
2.11	Hillsborough	-	-	-	-	-	-	Existing, DRI Mines and USS Agrichem
	Peace (east)	16.4/40.5	27.9/68.9	15.1/37.3	32.6/80.6	6.1/15.0	10.3/25.5	
	Peace (west)	1.6/4.0	5.5/13.6	.85/2.1	4.8/11.9	.61/1.5	2.0/5.0	
	Little Manatee	.73/1.8	3.6/8.8	.45/1.1	3.6/8.9	.28/0.7	1.3/3.3	
	Manatee	.28/0.7	2.2/5.5	.16/0.4	1.9/4.7	.12/0.3	.81/2.0	
	Alafia	6.3/15.6	12.0/29.7	5.8/14.3	13.8/34.1	2.3/5.8	4.5/11.0	
	Myakka	1.9/4.6	3.6/9.0	.97/2.4	3.2/7.8	.69/1.7	1.3/3.3	
2.11'	Hillsborough	-	-	-	-	-	-	All Identified Mines
	Peace (east)	16.4/40.5	34.0/84.1	15.1/37.3	36.7/90.7	6.1/15.0	12.6/31.1	
	Peace (west)	1.6/4.0	10.9/26.9	.85/2.1	8.4/20.8	.61/1.5	4.0/10.0	
	Little Manatee	.73/1.8	4.9/12.1	.45/1.1	4.5/11.1	.28/0.7	1.8/4.5	
	Manatee	.28/0.7	2.2/5.5	.16/0.4	1.9/4.7	.12/0.3	.81/2.0	
	Alafia	6.3/15.6	13.4/33.0	5.8/14.3	14.7/36.3	2.3/5.8	4.9/12.2	
	Myakka	1.9/4.6	7.5/18.5	.97/2.4	5.7/14.2	.69/1.7	2.8/6.8	

Table 1.6. Summary of Projected Production and Reclamation Acreage Projections by County and Scenario

		Hectares/Acres (thousands)					
		Mined		Reclaimed		Reclaimed 2.12(1)	
Scenario	County	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	Polk	18.5/45.7	29.8/73.7	18.2/45.0	35.8/88.5	20.9/51.6	36.7/90.6
	Hillsborough	1.4/3.5	2.8/6.9	1.4/3.4	3.4/8.3	1.6/3.9	3.4/8.5
	Manatee	-	-	-	-	-	-
	Hardee	-	-	-	-	-	-
	DeSoto	-	-	-	-	-	-
2.11	Polk	20.1/49.6	33.8/83.6	19.0/47.0	39.3/97.0	22.1/54.5	40.6/100.2
	Hillsborough	2.6/6.4	4.1/10.2	2.0/4.9	4.5/11.1	2.4/6.0	6.9/17.0
	Manatee	2.6/6.5	7.2/17.8	1.4/3.4	6.2/15.4	1.9/4.7	7.0/17.3
	Hardee	.97/2.4	7.2/17.9	.50/1.2	6.3/15.5	.69/1.7	7.0/17.4
	DeSoto	.77/1.9	1.7/4.1	.40/1.0	1.5/3.6	.57/1.4	1.6/4.0
2.11'	Polk	20.1/49.6	36.8/90.9	19.0/47.0	41.2/101.8	22.1/54.5	43.1/106.5
	Hillsborough	2.6/6.4	6.3/15.6	2.0/4.9	5.9/14.7	2.4/6.0	8.8/21.7
	Manatee	2.6/6.5	11.3/27.8	1.4/3.4	8.9/22.1	1.9/4.7	10.6/26.1
	Hardee	.97/2.4	14.1/34.9	.50/1.2	10.8/26.8	.69/1.7	9.4/23.3
	DeSoto	.77/1.9	3.6/9.0	.40/1.0	2.5/6.3	.57/1.4	3.4/8.3

Table 1.7. Summary of Projected Reclamation Acreage Projections to Land and Water by County and Scenario

		Hectares/Acres (thousands)							
		Land		Water		Land 2.12(1)		Water 2.12(1)	
Scenario	County	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	Polk	11.5/28.4	22.6/55.8	6.8/16.7	13.2/32.7	13.2/32.5	23.1/57.1	7.7/19.1	13.6/33.5
	Hillsborough	.85/2.1	2.1/5.2	.53/1.3	1.3/3.1	1.0/2.5	2.2/5.4	.57/1.4	1.3/3.1
	Manatee	-	-	-	-	-	-	-	-
	Hardee	-	-	-	-	-	-	-	-
	DeSoto	-	-	-	-	-	-	-	-
2.11	Polk	12.0/29.6	24.7/61.1	7.0/17.4	14.5/35.9	13.9/34.3	25.5/63.1	8.2/20.2	15.0/37.1
	Hillsborough	1.3/3.1	2.8/7.0	.72/1.8	1.7/4.1	1.5/3.8	4.3/10.7	.89/2.2	2.5/6.3
	Manatee	.85/2.1	3.9/9.7	.53/1.3	2.3/5.7	1.2/3.0	4.4/10.9	.69/1.7	2.6/6.4
	Hardee	.32/0.8	4.0/9.8	.16/0.4	2.3/5.7	.45/1.1	4.5/11.0	.24/0.6	2.6/6.4
	DeSoto	.24/0.6	.93/2.3	.16/0.4	.53/1.3	.36/0.9	1.0/2.5	.20/0.5	.61/1.5
2.11'	Polk	12.0/29.6	25.9/64.1	7.0/17.4	14.9/36.7	13.9/34.3	27.2/67.1	8.2/20.2	15.9/39.4
	Hillsborough	1.3/3.1	3.8/9.3	.72/1.8	2.2/5.4	1.5/3.8	5.5/13.7	.89/2.2	3.2/8.0
	Manatee	.85/2.1	5.6/13.9	.53/1.3	3.3/8.2	1.2/3.0	6.6/16.4	.69/1.7	3.9/9.7
	Hardee	.32/0.8	6.8/16.9	.16/0.4	4.0/9.9	.45/1.1	5.9/14.7	.24/0.6	3.5/8.6
	DeSoto	.24/0.6	1.6/4.0	.16/0.4	.93/2.3	.36/0.9	2.1/5.2	.20/0.5	1.3/3.1

SECTION 2

ISSUANCE OF EXISTING SOURCE PERMITS ONLY ("WITHOUT ACTION" ALTERNATIVE)

A. DESCRIPTION OF ALTERNATIVE

This scenario imposes the condition that only mining operations and processing plants permitted as of August 1, 1976, will be allowed to operate. Applicable permits relate to the Federal Water Pollution Control Act (PL 92-500), Sections 402 and 404, for existing sources; Environmental Protection Agency and Florida Department of Environmental Regulation requirements of the Clean Air Act; and other local, state, and federal permits applicable as of August 1, 1976, including reclamation.

According to information provided by EPA's Region IV, 18 mines and 15 processing plants are operating under existing permits. One of the mining companies also will reprocess old mine tailings for additional phosphate rock not previously considered economical to recover. In addition, several companies are expected to conduct scavenger operations to recover high-grade phosphate rock from old tailings (Hoppe 1976).

The immediate impact of the limitations just described is to eliminate the opening of any additional mining sites and to eliminate expansion or construction of new processing plants.

From current information on present production and reserves in permitted mines, the probable annual mining rates in the study area under the limitations established by this scenario have been estimated by mine (Figure 1.1) and have been compared with production rate projections under other scenarios (Figure 1.2). (Also in Section 1 of this Volume, the reader will find supply-demand projections [Figure 1.3] for Florida and the United States [U.S. Bureau of Mines 1975], world phosphate reserves and resources [Table 1.1] and reserves and resources for the 7-county study area [Table 1.2]).

Groundwater consumption is a matter of great concern throughout the study area. Water is used to transport the phosphate matrix as slurry to washers and beneficiation plants. Each ton of phosphate rock produced requires more than 3000 gallons of water; however, reuse and recirculation reduce the amount of water required for make-up and other losses to 1000 gallons per ton of rock (SWFWMD 1977). Based on the tonnage in Figures 1.1 and 1.2, Table 1.3 displayed a projection of water withdrawal for the phosphate mining industry based on the constraints imposed by this scenario. Ground water is the primary source of this supply, but one mine now obtains a portion of its supply from surface water and another plans to do so in the near future. With current emphasis on conservation of water resources, the mining companies probably will be able to reduce their make-up water requirements further.

For phosphate chemical processing plants, water consumption cannot be estimated on the basis of per ton of rock mined because not all of the mined rock is processed locally; the processing plants can operate on imported phosphate rock supplies as the land supply diminishes. However, the 15 permitted plants in the study ares use an estimated 93,040,000 gallons per day.

The primary source of energy for the phosphate mining and processing industry is electricity. The main supplier of electric power in the study area is Tampa Electric Company, with lesser amounts supplied by Florida Power Corporation and Florida Power and Light Corporation. During 1975, electrical energy requirements by the phosphate mining and processing industry in the study area totaled approximately 3.845 billion kilowatt-hours. Under the arrangement between the phosphate companies and the power companies, a substantial portion of the electrical service is interruptible during periods of peak demands or emergencies. Thus, the service is provided at lower rates than would be possible without the interruptible feature. Florida Power Company reports that this eliminates the need for 200 megawatts of generating capacity for peaking purposes (FPC, FP&L, TEC personal communications 1977).

Mining operation emissions to the atmosphere are relatively minor. Particulate matter resulting from open burning during land clearing and fugitive dust from mining operations would be the primary concerns. Processing plants are monitored for particulates, fluoride, sulfur dioxide, nitrogen oxide, and acid mist, depending on the type of process.

Liquid waste discharges must meet the standards set by the National Pollution Discharge Elimination System for existing sources as administered by the Environmental Protection Agency.

The Florida Department of Environmental Regulation (DER) has established a branch office in Polk County (Winter Haven) to enforce environmental regulations with regard to the phosphate industry.

The regulation under which the Florida Department of Natural Resources regulates mine reclamation is Chapter 16 C-16 of the Florida Administrative Code; no reclamation program can include more than 640 acres, which must be contiguous. Use of reclaimed land requires consideration of the radiation environment resulting from mining and reclamation activities. A detailed discussion of this subject appears in Volume VI, Section 4 (TI 1977f). (Tables 1.4 through 1.7 presented mining and reclamation acreages estimated to occur under Scenarios 2.15, 2.11, and the "industry view" 2.11').

B. MATRIX AND SUPPORTING RATIONALE FOR IMPACT ASSESSMENT

1. Natural Environment

a. Atmosphere

1) Climate/Weather

Recent studies indicate that weather patterns around large urban areas can be affected by the local influence of man's activities (Sullivan 1977). However, it is unlikely that the alteration of the land surface and extent of air pollutants emitted by the phosphate industry will combine to have such an effect in central Florida. Because of the scattered nature of the phosphate

activities, as opposed to the intense combination of effects caused by major urbanization, values of "0" will be assigned in this column for all of the technological demand elements.

2) Air Quality

The effect of the phosphate industry on four air pollutants - SO_2, particulates, fluorides, and radon - was reviewed in Volume IV, Section 2 (TI 1977d). Included was an emission inventory for SO_2, particulates and fluorides for 1974 and 1976 and a review of the existing air quality data base for these parameters. Based on this, it was decided that the impact assessment of the phosphate industry could best be based on the emission levels of SO_2 and particulates. Radon was not included in the impact analysis because no quantitative data exist on radon emission rates either from disturbed or undisturbed soil. In addition, existing measurement data on radon levels in the atmosphere have not been collected with a standard methodology and have been oriented toward finding ambient "hot spots" rather than evaluating existing ambient levels throughout the study area. Fluorides were not included in the impact analysis for several reasons. First, the ambient levels reported throughout the study area have been very low since 1974 and have shown little correlation with measured fluoride levels in pasture grass; in fact, the levels reported for atmospheric fluorides have been below the value established by the DER as the minimum sensitivity for the sampling method. Finally, areas in which vegetative damage is known to exist are primarily on phosphate industry property or property for which "air rights" have been transferred to the industry.

The impact was evaluated using emission projections and estimated ambient pollutant levels in the following algorithm:

$$\text{Impact} \approx -\sum_{i,j} \left[\frac{\text{industry emissions}}{\text{total county emissions}} \times \frac{\text{ambient level}}{\text{state standard}} \right]_{i,j}$$

where index i corresponds to the pollutant parameters (SO_2, particulates) and j to the counties in the study area. The impact parameter is defined to

be negative and can be scaled by a linear or nonlinear scaling factor to conform to the range of values used in other elements of the effects matrix.

a) Scaling the Impact Algorithm

First, considering the magnitude of the values that will arise from the summation term in the impact algorithm under various conditions, it will be necessary to adjust the impact values calculated with the algorithm to fit a scale of 1-10 to conform to other inputs into the matrix. This may be done linearly with a scaling factor or in a more arbitrary way based on a subjective evaluation of the impact under any given conditions. The latter method will be used to fill in the matrix column 41, using the correlations developed below. For any technological demand element, the impact of a single industry could be called "very severe" if it generated one-half the pollutants in each category evaluated in each county and if the ambient levels were at one-half the state standard. (The algorithm would yield -3.5 in this case.) The impact could still be considered "severe" if one- half the pollutants in each county were generated by one industry, with two counties at one-half the state air standard for ambient levels of pollutants and the remainder at 20 percent of the standards. (The algorithm would yield -2.0 in this case.) If the emissions were one-half the county totals, but ambient levels were 20 percent or less of the state standards, the effect could be called "moderate." (The algorithm yields -1.4 in this case.) The effects would be "light" if the industry accounted for less than one-fourth the pollutants in each county with ambient levels below 20 percent of state standards. (The algorithm would yield -0.7 in this case.) The impact would be "very light" if the industry accounted for only one-fourth the emissions with ambient levels below 10 percent of the standards. (The impact algorithm would yield -0.35 in this case.)

The preceding can be summarized in tabular form as follows:

Calc. Value*	Level of Effect	Matrix Entry
-3.5	Very severe	-10
-2.0	Severe	-7
-1.4	Moderate	-5
-0.7	Light	-2
-0.35	Very light	-1
-0.1	Negligible	0

*Calculated from impact algorithm for two pollutants, seven counties.

b) Air Quality Estimates

The air quality estimates were based on the reported 1976 data (TI 1977d:Volume IV, Section 2) adjusted up or down slightly in each county, depending on the direction of the emissions projected for 1985 and 2000 in that county. The estimated changes were not based on modeling. The estimated county averages of TSP used in the impact assessment were as follows:

	Micrograms per Cubic Meter		
County	1976	1985	2000
Charlotte	26	28	30
DeSoto*	35	36	37
Hardee	35	36	37
Hillsborough	51	52	53
Manatee	36	37	38
Polk	49	49	50
Sarasota	42	43	44

*Assumed same as Hardee; DeSoto data seem biased.

Estimating SO_2 levels was much more difficult because the 1976 data were subject to errors (TI 1977d:Volume IV, Section 2). The following estimates were used in the impact assessment:

County	Micrograms per Cubic Meter 1976-85	2000
Charlotte*	0	0
DeSoto*	2	12‡
Hardee**	4	4
Hillsborough*	24	24
Manatee*	4-7†	7
Polk***	40	38
Sarasota*	2	2

*Assumed to be twice reported averaged.

**Reported <13 by CF Industries; assumed same as Manatee.

***Calculated from 1976 emissions using EPA area source model (USEPA).

†Increase in 1977 because of power plant.

‡Assumed to be one-half 1976 Hillsborough value because of new power plants.

The values shown for SO_2 levels are not in themselves adequate for evaluating the effects of the phosphate industry because of the uncertainties involved in the assumptions made to generate the table; they are, however, adequate for use in the impact algorithm presented earlier, which is based primarily on the emission levels of pollutants. The trends in air quality for the quantified technological demand elements (T.D.) are shown below for Scenario 2.15.

T.D. Element	1985	2000
4	+	+
12	+	+
13	+	+
17	+	+
18	+	+
19	+	+
20	+	+

Apparent improvement only indicates a trend toward lower impact by phosphate industry under this scenario. Phosphate emissions decrease slightly under mining and drying (rows 4, 13) and decrease quite a bit under production of H_2SO_4 (row 17), relative to 1976 levels. Other categories remain about the same, but county overall emission levels increase to reduce

the industry impact as evaluated by the impact algorithm described earlier. The actual impact values calculated for Scenario 2.15 are shown below, along with the weighted matrix entries.

	1985		2000	
T.D. Element	Calc.	Matrix	Calc.	Matrix
4	-0.002	0	-0.0004	0
12	-0.107	-1	-0.092	0
13	-0.135	-1	-0.018	0
17	-0.278	-1	-0.310	-1
18	-0.071	0	-0.068	0
19	-0.010	0	-0.009	0
20	-0.028	0	-0.027	0

b. Land

1) Physical and Chemical

This subsection deals primarily with effects imparted to the physical environment of the study area as a result of actions by the phosphate industry. Effects imparted to the chemical environment are inherent in industry operations; i.e., the nature of the industry is to alter the chemistry of the materials removed from the environment (TI 1977a:Volume I). A full discussion of the geochemistry of the overburden, aluminum phosphate, matrix, and bedclay zones appears in Volume VI, Section 3 (TI 1977f). Within the discussions of the physical environmental elements that follow, however, the reader will also find comments dealing with the effects of alteration of the chemical environment in the mining areas, where appropriate. For example, impacts of the chemical alteration of matrix-zone materials are discussed in terms of resource depletion of phosphate and uranium in the subsections dealing with resource usage as well as economics. This approach to chemical environmental effects is applicable also in corresponding sections of this document.

a) Unique Physical Features

The natural physical features of the study area include sand terraces, geologic ridges (e.g., the Lake Wales Ridge), surface and subsurface sinkholes, and other minor features typical of flat, low-lying terrain. Of these, the ridges and solution cavities may be considered unique. The

activities of the phosphate industry have no essential effect on these features except for the potential to effect sinkholes via accumulated waste clay slimes and gypsum. Unique man-made physical features created by the industry (excluding such cultural features as buildings, pipelines, and access roads) are predominated by open-mining cuts, large storage piles of phosphate rock and gypsum, and large impoundments for clay slimes and cooling waters.

(i) Slime Placement (Line 15)

If slime is placed so that the final surface is near or elevated over the original grade, there will be increased loading on the underlying supporting limestone. A solution chamber below the slime-settling area increases the potential for roof collapse because of the increased weight. No data exist, however, to support quantification of the potential for collapse of any slime pond due to this loading; therefore, a negative effects rating is given in the Scenario 2.15 matrix (Plate 4 in pocket) for this section, for both the short and long term.

(ii) Waste Treatment (Line 21)

Waste treatment at the chemical processing plants is dominated by the liming treatment of process water from phosphoric acid plants. If untreated, waste water possesses a low pH and is potentially contributory to the enlargement of underground caverns. However, no effects on this environmental demand element are quantified because treatment is required to meet effluent discharge standards, process waters are essentially controlled and/or contained by dikes and ditches, and recirculation is virtually total. Because the activity of waste treatment can be thought of as mitigating a potential negative effect, it is a positive entry on the matrix.

(iii) Waste Placement (Line 22)

Wastes that emanate from the chemical processing of phosphate rock and could effect the unique natural physical features of the area exist predominantly in the waste gypsum stack. As in the case of slime ponds, the highest potential effect is associated with ground loading, which could

potentially collapse solution cavities that might exist or develop under the stack. The most recent sinkhole collapse under a gypsum stack occurred in 1975 under a stack owned by C.F. Industries, Inc. (Kaufman and Bliss 1977).

The quantity of gypsum waste accumulated is a direct function of the amount of phosphoric acid produced. Although continued waste accumulation may tend to increase the likelihood of stack collapse, quantifying this potential is not possible; however, the effect on this environmental demand element is considered negative.

b) Soils

In Volume VI (TI 1977f), the soils in the study area are mapped at the soil association level (Plate 2), the potential of these soil associations for agriculture given (Plate 5), and area boundaries within which phosphate mining is projected for this scenario for 1977-85 and 1986-2000 presented (Plate 3). Table 2.6 showed that 25 of the 45 identified and mapped soil associations in the 7-county study area have a high potential for citrus and/or truck crops. By overlaying the mapped soil associations (with those of high potential identified) on the mine boundary map showing forecasted area of mining, the number of acres of high-potential soils that will be destroyed by industry activities under this scenario was estimated. It must be pointed out, however, that reclamation often results in soils that are better than the original soils in terms of moisture-holding capacity, permeability, and other beneficial soil characteristics relative to agriculture and that use of the phrase "destruction of soils" is not entirely proper. On the other hand, mining and reclamation do change the character of the original soil so that it loses its original identity, thus the use of the term "destroy".

Under Scenario 2.15, more than 4,856 hectares (12,000 acres) of high-potential soils will be destroyed between 1977 and 1985 and more than 8,500 hectares (21,000 acres) between 1977 and 2000, as determined by the techniques described above.

Some industry activities disturb generally the uppermost surface of soil; such disturbances usually are highly localized and/or of a temporary nature and therefore considerably less important in effects assessment than when the character of the original soil is destroyed. Example activities would be building a temporary road or drilling prospect holes.

(i) Prospect Drilling (Line 1)

This activity results in a highly localized disturbance of the soil. Areas to be mined under this scenario have been previously prospected to a significant level of detail, so few if any additional prospect drill holes are anticipated. Because the effect of the activity on soils is minor, a "0" is entered on the matrix for Scenario 2.15.

(ii) Water-Well Drilling (Line 2)

As in prospect drilling, this activity results in only minor disturbance of soils. Thus it is assigned "0" on the matrix.

(iii) Clearing (Line 4)

This surface activity results in a minor disturbance of soils and thus is given a "0" on the matrix.

(iv) Burning (Line 5)

Burning surface vegetation presents a localized potential for changing the chemistry of the soil, but the effect is considered minor. Thus, a "0" entry is made on the matrix.

(v) Draglining (Line 6)

As estimated by the approach previously described, 4,879 hectares (12,055 acres) of soils of high agricultural potential are forecast to be destroyed in the 1977-85 time frame and 8,532 hectares (21,082 acres) between 1977 and 2000. Thus, negative entries are required on the matrix.

(vi) Overburden Placement (Line 8)

The initial cut in mining a new segment requires that a relatively small amount of overburden be placed above grade and on top of original soils. The effect of this activity is on the soil A horizon and is minor. Thus, a "0" is entered on the matrix.

(vii) Construction Activities (Lines 24-26 and 29)

Industry construction involves dams and levees (Line 24), access roads (Line 25), utility lines (Line 26), and drainage systems (Line 29), all of which locally and/or temporarily disturb soil. Thus, the effect is considered minor, resulting in "0" entries on the matrix for these activities. No new washing/beneficiation or processing plant construction are forecast under this scenario.

(viii) Reclamation of Mining Pits and Slime Ponds (Lines 21 and 32)

The reclamation of mining pits involves the use of quartz sand tailings and overburden materials, including top soil that is often saved for top dressing of the reclaimed area and leach-zone materials when present. As mentioned previously, land reclaimed for agriculture has the potential for increased production over the original land, but to realize such potential requires application of a high degree of management, including control of drainage, application of the correct soil nutrients, and proper irrigation. (Because of the complexities involved, no attempt was made to quantify the changes that may exist in soil productivity of reclaimed land compared with the virgin land in the areas forecast to be mined under this scenario.)

Reclamation establishes a surface that generally favors development of useful soil. Because the potential for soil productivity improvement exists, a plus is entered on the matrix. However, in terms of agricultural potential, soils developed on reclaimed mine pits would contrast markedly with those of reclaimed slime ponds (using current natural settling techniques) primarily because of the low porosity and permeability of the

dewatered slimes. Thus, the reclamation of slime ponds was given a "0" on the matrix. It is forecast that both mine pit and slime pond reclamation plans will call for a top dressing usually involving 2 feet or more of top soil/overburden mix saved for that purpose.

c) Exposure

Exposure is defined as exposing the geologic section to study and analysis, and industry activities that result in information about the geologic section constitute a positive effect.

The activity with the most significant effect on exposure as defined is prospect drilling, which involves core sampling to develop information pertinent to mining plans (TI 1977a:Volume I). For this scenario, however, prospect drilling is assumed to be essentially complete since mine plans have already been developed for the scenario mines.

(i) Water-Well Drilling (Line 2)

Drilling connector wells to dewater mine areas represents a potential to develop further information regarding the geologic section of the area, thus the positive entry on the matrix. However, information developed by this activity would not significantly enhance previously existing knowledge about the section. This scenario anticipates no new water-supply wells.

(ii) Draglining (Line 6)

Draglining to open the mine pit offers an excellent opportunity to collect detailed information about the section, so it has a positive effect on exposure. The effect is considered minimal, however, since this scenario involves only continued production from existing mines (no new mines). Thus, it has a "0" entry on the matrix.

(iii) Tailings Placement (Line 14)

Placing tailings in the mine pit tends to preclude further local study of the section and is hence a negative effect. However, section information will have already been developed, so the effect of this activity will be insignificant and thus is assigned a "0".

(iv) Slime Placement (Line 15)

Placing slimes in an impoundment within the mining cut eliminates exposure, thus precluding further study. Since section information will have been previously developed, however, a "0" is entered on the matrix.

(v) Reclamation of Mine Pits (Line 31)

Reclamation of mine pits is the final act that totally eliminates exposure of the section. Final grading and contouring eliminate any exposures not previously eliminated by the placement of sand tailings (Line 14). However, the significance of this act cannot be quantified, so it is given a "0" on the matrix.

d) Topography

Industry activities that change the natural surface by moving (digging or piling) earth materials are considered to affect topography negatively. Excavating, storing phosphate rock, piling waste sand tailings and gypsum, and storing waste slimes and process water in large impoundments cause topographic changes.

(i) Draglining (Line 6)

Excavating by dragline is considered to have a negative effect on topography. The magnitude of the effect under this scenario is proportional to the number of acres mined between 1977 and 1985 (the short term, estimated to be 19,870 hectares [49,100 acres]) and between 1977 and 2000 (the long term, estimated to be 32,620 hectares [80,600 acres]). (The estimates were based on the industry phosphate rock tonnage projections for the periods divided by an areawide average of 7,300 tons of rock per acre mined.)

(ii) Overburden Placement (Line 8)

Overburden placement for initial cuts of a mine segment are above grade, thus having a negative effect on topography. Although considered negative, however, this is a localized and temporary condition (until reclamation) of minor magnitude.

(iii) Product Storage (Line 12)

Phosphate rock is stored locally in large piles that are considered to alter natural topography. In the short term (to 1985), the size of product storage piles is expected to remain constant or enlarge slightly; in the long term (to 2000), the trend will be toward elimination. Thus, the short-term effect is negative and the long-term effect is positive as existing stockpiles disappear. No new piles are anticipated.

(iv) Tailings Placement (Line 14)

Tailings placement is considered to have a positive and somewhat offsetting effect to draglining; the bulk of tailings end up in the mining cuts, thus bringing the mine-cut surface nearer to the initial elevation. Only after reclamation, however, does the topography of the area approximate that of the original surface. Thus, a "0" is entered on the matrix to signify that the effect of mining has not been offset by this activity.

(v) Slime Placement (Line 15)

Slime placement is also considered to have a positive and offsetting effect on topography. However, for slime reclamation using present natural settling techniques, the final topographic surface only approximates that of the original surface. Thus a "0" is entered on the matrix.

(vi) Waste Placement (Line 22)

The placement of gypsum wastes at the phosphoric acid plants constitutes an alteration of the local topography. Gypsum will continue to accumulate at a rate proportional to the quantity of phosphoric acid

produced over the period of this scenario. The continued stacking of gypsum constitutes an increasing negative effect on topography in both the near and long term.

(vii) Construction of Dams and Levees, Transportation Lines, and Drainage Systems (Lines 24, 25, and 29)

Construction of dams and levees (Line 24), transportation lines (Line 25), and drainage systems (Line 29) imparts a negative effect on local topography. However, since only a small total area is involved (relative to areas mined), "0" entries are made on the matrix.

(viii) Reclamation of Transportation Systems, Mining Pits, and Dams and Levees (Lines 30, 31, and 35)

Reclamation of these constructed items constitutes the final step in reestablishing land contours as nearly as possible (the exception being where specific reclamation plans establish a deviation) to original contours. Thus, reclamation as it is presently practiced generally has a positive (offsetting) effect on topography.

e) Background Radiation

Under Scenario 2.15 no new chemical processing plants or washing/beneficiation plants are forecast to be constructed. Therefore, both short-term and long-term effects on (i.e., changes in) background radiation by industry actions will be essentially concentrated in the areas forecast to be mined during the respective terms. Exceptions would include the continued accumulation of waste products at the chemical plants and continued transportation of mine and processing plant products. Included are the ongoing movements of earth materials during construction of dams and levees, transportation lines, and drainage control systems. The effects of these activities on background radiation are judged on the basis of estimated changes in background gamma radiation levels as a function of changes in radioactivity concentrations of radium-226 in earth materials constituting the surface affected. For example, mining displaces the original surface

and exposes bedclay and residual matrix materials in an active pit; tailings placement in the pit results in a temporary surface of quartz sand; and reclamation results in a new surface containing a mixture of overburden, sand tailings, and top soil. These surfaces have different radium-226 radioactivity concentrations. If an activity results in a surface with increased radium-226 radioactivity concentrations, the effect is considered negative; if lowered, the effect is considered positive. Impacts (estimated in the following sections comparing scenarios) are based on effects calculations coupled with human occupancy factors for the areas involved. Representative radium-226 concentrations for materials found in the study area are presented in Table 2.1.

(i) Overburden Placement (Line 8)

The initial cut in a mining sequence requires the stacking of a relatively small amount of overburden above grade. This is a temporary situation in most mining and reclamation plans but does cause new small-area surfaces having increased radium-226 content. As a point of comparison, soil radium-226 concentration is 1.5 picocuries per gram but is 10 picocuries per gram for overburden without leach zone, 40 picocuries per gram for leach-zone materials, and 40-60 picocuries per gram for matrix. Therefore, this activity tends to increase background radiation level slightly in highly localized areas. Thus, this activity is assigned a "0" on the matrix.

(ii) Water Injection (Line 10)

Injecting water-table water into the Floridan aquifer through connector wells to assist in mine dewatering transfers the lower radium-226 content waters. The radium-226 content in water-table water is 0.7 picocuries per liter; for water of the lower Floridan aquifer, 1.5 picocuries per liter. The effect, though minor, could be positive in that the dilution of the lower ground water by higher quality water is effected. However, "0" was entered on the matrix.

Table 2.1. Representative Radium-226 Concentrations in 7-County Study Area Environment

Item	Radium-226 Concentration	Reference
Background soil	1.5 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Silt	1.1 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Beach sand	0.9 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Reclaimed soil	10-30 pCi/g	Mills et al (1977)
Overburden (excluding leach zone)	10 pCi/g	Kaufmann and Bliss (1977)
Leach zone materials	40 pCi/g	Kaufmann (1977)
Matrix	40 pCi/g 60 pCi/g	Florida Department of Health and Rehabilitative Services (1975) Guimond and Windham (1975)
Wet phosphate rock	29-34 pCi/g 42 pCi/g	Florida Department of Health and Rehabilitative Services (1975) Guimond (1976a)
Sand tailings	7.5 pCi/g 6.2-8.8 pCi/g	Kaufmann and Bliss (1977) Florida Department of Health and Rehabilitative Services (1975)
Slime particles	45 pCi/g 33-52 pCi/g	Kaufmann (1977) Florida Department of Health and Rehabilitative Services (1975)
Slime decant water (dissolved fraction)	1-2 pCi/ℓ	Florida Department of Health and Rehabilitative Services (1975)
Slime decant water (undissolved fraction)	33.5-52 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Mine water	<1.5 pCi/ℓ	Kaufmann and Bliss (1977)
Ground water	<1.5 pCi/ℓ	Kaufmann and Bliss (1977)
Slime-pond water	<2 pCi/ℓ	Kaufmann and Bliss (1977)
Leachate from gypsum pond	60-100 pCi/ℓ	Kaufmann and Bliss (1977)
Gypsum	21-33 pCi/ℓ	Kaufmann and Bliss (1977)
Phosphate products (undifferentiated)	42 pCi/g	Kaufmann and Bliss (1977)
Phosphoric acid plant effluent after double liming	1.8-4.5 pCi/ℓ	Guimond and Windham (1975)
Slag from calcination processes	56 pCi/g	Guimond and Windham (1975)
Ammonium phosphates	5-6 pCi/g	Guimond (1976a)
Superphosphates	21 pCi/g	Guimond (1976a)
Phosphoric acid	<1 pCi/ℓ	Guimond (1977)
Animal feed supplements	5-6 pCi/g	Guimond and Windham (1975)

(iii) Product Storage (Line 12)

Under this scenario, product storage piles are expected to remain essentially constant (or to slightly increase in the short term) in terms of tons of marketable rock stored. In the long term, storage piles will be depleted as mining is curtailed. The long-term elimination of storage piles will tend to slightly lower the background radiation levels, an act considered positive. The short-term effect, however, is constant and is assigned a "0".

(iv) Product Drying (Line 13)

Product drying activities release dust particles containing radionuclides. The release of these materials is considered one of the major areas of concern and is considered negative in both the short and long term. However, effective control measures are in use.

(v) Tailings Placement (Line 14)

Sand tailings contain about 8 picocuries per gram of radium-226, which is essentially equal to that for unmined bedclays; therefore, covering the bedclays with sand tailings would not be expected to essentially change background radiation levels in the mine cut. However, residual matrix in the pit would be covered, which would tend to yield a slight positive effect for this activity.

(vi) Slime Placement (Line 15)

Placing slime in the mining pits tends to increase background radiation because of the relatively high radium-226 content of the slime particles (approximately 45 picocuries per gram). However, active slime impoundments with a surface of decant water (1-2 picocuries per liter) would provide a buffering medium of very low radium-226 content. Once the surface has been dewatered (with solid slimes constituting the surface), background radiation would be expected to increase over that for original soils. The short-term and long-term effects of slime placement (ignoring reclamation at this point) are positive because of the decant water cover.

(vii) Fertilizer Products (Line 18)

Fertilizer products have been shown to contain radium-226 in radioactivity concentrations ranging from 5 to 21 picocuries per gram, as well as much higher concentrations of other radionuclides (TI 1977f:Volume VI, Table 4.10 and Section 4.C). Under Scenario 2.15, the chemical processing plants are expected to continue operating at an essentially constant level through the year 2000. Thus, negative entries are made on the matrix for both the short and long term.

(viii) Animal-Grade Phosphate (Line 19)

Animal-grade phosphate (radium-226 concentrations of 5-6 picocuries per gram) will continue to be produced under this scenario. This calls for a negative entry on the matrix.

(ix) Waste Treatment (Line 21)

Waste treatment at the phosphate industry's chemical processing plants is dominated by double-liming techniques associated with effluents from the production of phosphoric acid. Outfall radium-226 concentrations after double liming have been given as less than 2 picocuries per liter, a concentration value approximating those of waters from the ground aquifers. The treatment of waste process water has a positive effect because it precludes any significant increase in background radiation of surrounding areas inasmuch as the radium-226 removed is retained in the relatively small treatment ponds. Total recirculation of waste water from these plants is an industry objective; all plants recirculate more than 90 percent, and one is achieving 100 percent.

(x) Waste Placement (Line 22)

Waste placement includes the accumulation of gypsum in large waste piles (stacks) and the accumulation of slag from the production of elemental phosphorus through calcination. The radium-226 radioactivity concentration in gypsum is between 21 and 33 picocuries per gram; in slag, 56 picocuries per gram. Under this scenario, gypsum and slag will continue to be produced

at a rate proportional to the production of phosphoric acid and elemental phosphorus, which is assumed to continue at current rates through 2000. Changes in background radiation will occur if new gypsum stacks are created, but the stacks are likely to contain significantly less radium-226 because of the use of imported rock after 1985, especially if the imports come from Morocco (Figure 2.1). The matrix entry is therefore negative for both the short and long term.

(xi) Construction of Dams and Levees, Transportation Lines, and Drainage Systems (Lines 24, 25, and 29)

Construction of dams, levees, transportation lines, and drainage systems involves the use of materials that are generally higher in radium-226 than is the undisturbed native soil. Grading activities, which strip low-concentration topsoil and expose the higher radium-226 radioactivity of the remaining overburden, tend to alter radiation background levels only slightly. Although "0" entries are made on the matrix for both the short and long erms, these activities (alterations) are expected to continue.

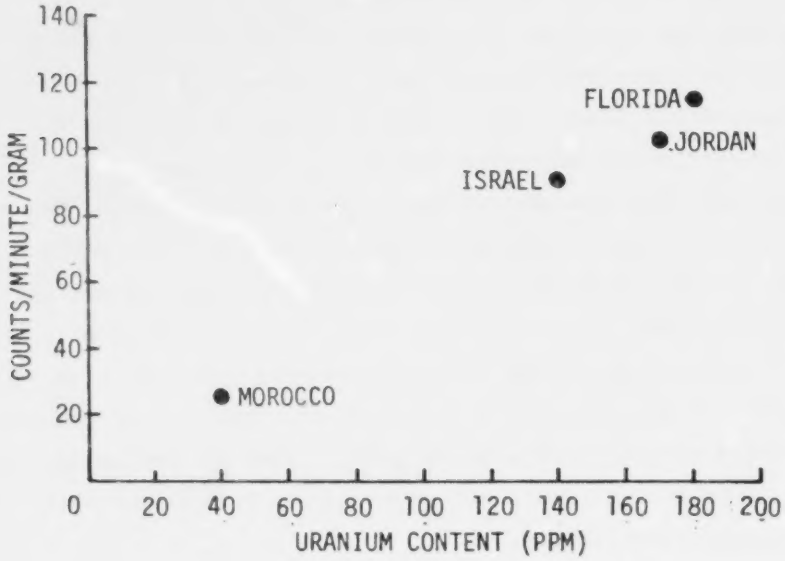


Figure 2.1. Relation Between Total Gamma Activity and Uranium Content of Sedimentary Phosphates (Habashi 1966)

(xii) Reclamation of Mine Pits and Slime Ponds
(Lines 31 and 32)

Reclamation of mine pits means the final contouring and top dressing of pits previously filled with sand tailings, overburden, and/or slime. Of mined-out areas industrywide, an estimated 50 percent will be used for slime retention, 37 percent will be reclaimed to open water, and 13 percent will be reclaimed to a potentially productive land use in the near term. Current slime-pond reclamation processes will increase the radioactivity background of the pond area over that existing before reclamation (see the discussion of dewatering, Line 15). Concentration in open water will be significantly lower than that of original soils or an unreclaimed pit containing overburden and waste sand tailings. Concentration in the balance, if top-dressed with soil saved for that purpose, would tend to be slightly higher than original concentrations. It is estimated that a mine segment consisting of 50 percent active slime ponds and 50 percent mined land yet to be reclaimed will exhibit an overall average radium-226 background radioactivity approximating 10 picocuries per gram for areas containing leach-zone materials and 5 picocuries per gram where the leach zone is absent. Following grading but prior to top dressing, the slime-pond portion of this same segment will be dewatered (raising the surface concentration to approximately 45 picocuries per gram, 37 percent will be water (essentially 0 radium content on a per-gram basis), and the balance a mix of sand tailings and overburden (minus leach zone). Such a situation will yield an average background concentration approximating 24 picocuries per gram. Using the above assumptions, the average radiation level will increase only slightly (to approximately 26 picocuries per gram) where leach-zone materials are present. After final grading, which includes top dressing the settled slime pond and the overburden/sand-mix areas with at least 2 feet of overburden/topsoil mix, the average radium-226 radioactivity concentration is expected to approximate 9 picocuries per gram, or about the same for the total segment fully mined with an active slime pond. From the preceding, top dressing appears to be a significant act of reclamation relative to achieving low final background radiation levels.

Under this scenario, approximately 19,590 hectares (48,400 acres) are expected to be reclaimed between 1977 and 1985 and 39,170 hectares (96,800 acres) between 1977 and 2000. These figures include reclamation of slime ponds created in the years prior to 1977. Based on this, the act of reclaiming mined areas will have little effect on background radiation; i.e., this act is expected to result in little change over that of an active mine. Hence, the matrix is given a "0" for both the short and long term. Reclamation will have a significant positive effect on background radiation relative to simple abandonment of mined areas, but this is not forecast to happen under any of the scenarios considered.

(xiii) Reclamation of Dams and Levees (Line 35)

Reclaiming dams and levees generally involves regrading these structures to approximate the original topography. Whether this action will reduce the background radioactivity of the area will depend on the final disposition of the materials. If the materials are deposited in old nearby mine cuts as assumed, the radium-226 concentrations will be only slightly reduced at the point of removal. Thus, the activity is given a "0" effect rating.

(xiv) Transportation of Mine Products (Line 37)

Currently, mine products are transported by slurry pipeline. Because the transported materials are confined to the pipeline, continued operation of the pipeline would be expected to cause very little or no increase in background radiation. However, there is the potential for pipe failures, although small. Thus, the short term is given a negative entry. For the long term, the tonnage mined tends toward "0" with the potential for pipe failure following; however, the long-term effect is also considered negative.

(xv) Washing/Beneficiation Plant Products (Line 38)

Marketable phosphate rock accumulated through the washing and beneficiation of mine products is transported from the plant predominantly

by rail. Minor spillage along the right of way may result in a slight increase locally in the radium-226 radioactivity concentrations of the surface. Thus, a "0" effect entry is made on the matrix for both time periods. Again, tonnages are forecast to decline toward 0 by the year 2000.

f) Noise

Under Scenario 2.15, noise levels will decline consistent with the phase-out of mining activities toward the year 2000. Mining of phosphate, however, does not create noise levels high enough to represent an undesirable effect on area population not associated directly with the industry. Ambient noise levels increase locally during mining and reclamation operations, especially in the immediately vicinity of operating bulldozers and draglines. Operations personnel are easily protected from noise through administrative or engineering controls, or by means of protective equipment. Thus, no effects are indicated under this or other scenario.

2) Biological

Further development of the central Florida phosphate industry will significantly affect the existing uplands and wetlands biota of the 7-county study area. Beyond devegetation or disturbance, it is generally estimated that as much as 30 percent of the terrestrial habitat in mined areas will become aquatic habitat, primarily lakes and ponds; natural or cultivated vegetation and faunal species of the converted habitat, for practical purposes, will be permanently displaced. Because of essentially irreversible alterations in local topography and soil structure of remaining land, restoration of certain existing plant communities is not probable, resulting in overall changes in vegetation cover, associated fauna, and landscape.

Further perturbations are inherent in existing reclamation regulations and practices. Reclamation is producing a more uniform habitat (Borden 1975). Natural systems of high diversity are replaced for the most part by systems of comparatively low diversity as well as low productivity. In the substantially modified environment of central Florida, the remaining

extent of essentially undisturbed systems represents an important natural resource. Because data of appropriate detail are unavailable, it is impossible to estimate reliably these natural systems' present or future areawide extents. Clearly, however, they will be diminished: by the year 2000, for instance, a greater loss of wetlands will occur in Polk County alone than is projected for the entire study area (Table 2.2 and TI 1977c:Volume III, Chapter 4, Table 2.1).

To the extent possible, the effects of phosphate mining activities on uplands/wetlands biota presented in the working paper Terrestrial Biota (TI 1977f:Volume VI, Section 5) are assessed herein. In most instances, data relevant to the assessment appear in the working paper; this especially includes lists of plants and vertebrate fauna associated with various habitat types, as well as sources of data and meanings of important species categories.

Table 2.2. Acreages of Habitat Types Mined within Permitted Areas (Scenario 2.15) and Permitted and Pending Permits (Scenario 2.11)*

	Habit Type (Level-I, USGS)	Hectares/Acres Mined by 1985	% of 1975 Areawide Acreage	Hectares/Acres Mined by 2000	% of 1975 Areawide Acreage
Scenario 2.15	Cropland and pasture	3,807/9,408	1.3	8,651/21,376	3.1
	Orchards, groves	130/320	-	907/2,240	0.7
	Rangeland	3,833/9,472	0.9	6,682/16,512	1.5
	Forest (primarily evergreen)	3,056/7,552	4.4	4,843/11,968	7.0
	Uplands (total)	10,827/26,752	1.1	21,083/52,096	2.2
	Wetlands	3,004/7,424	1.7	5,129/12,673	2.8
	Terrestrial (total)**	13,831/34,176	1.2	26,212/64,769	2.3
Scenario 2.11	Cropland and pasture	7,175/17,728	2.5	17,846/44,096	6.3
	Orchards, groves	155/384	-	1,347/3,328	1.0
	Rangeland	6,657/16,448	1.5	18,260/45,120	4.0
	Forest (primarily evergreen)	4,041/9,984	5.8	7,459/18,432	10.7
	Uplands (total)	18,027/44,544	1.9	44,912/110,976	4.8
	Wetlands	4,973/12,288	2.8	10,878/26,880	6.1
	Terrestrial (total)	23,000/56,832	2.1	55,790/137,856	5.0

*U.S. Corps of Engineers Four River Basins Study (1976).
**Includes 51.8 hectares (128 acres) of deciduous forest from LUDA map.

a) Habitat Types

Assigned to each major uplands/wetlands habitat type was an importance ranking to serve as a weighting factor in judging effects (Table 2.3). The approximate number of all terrestrial vertebrate species associated with each type was considered, as well as the number of threatened and endangered, commercial and recreational, and ecologically significant vertebrates. Other factors included in the evaluation of the major types where applicable were:

- Vulnerability

  As defined by the Florida Department of Natural Resources (1975), vulnerability is a system's susceptibility to degradation because of man's activities, whether nearby or remote. Under Florida's environmentally endangered lands plan (EEL), vulnerability ratings (high, moderate, or low) are assigned to certain habitat types.

- Endangerment

  Also defined and assigned to certain habitat types by the DNR, endangerment refers to the potential (high, moderate, or low) for actual destruction or degradation of the system by man's activities.

- Priority Communities

  In connection with a survey of the wildlife values of Florida's plant communities, a priority ranking (primary or secondary) of plant communities indicating those most deserving of protection was assigned by the Florida Game and Fresh Water Fish Commission (FGFWFC). The rankings are based on wildlife value, scarcity within each of nine major Florida watersheds, and endangerment of the various habitat types. Most of the study area lies within the Peace-Withlacoochee-Hillsborough watershed; the easternmost part of Polk County is in the Kissimmee River watershed, and the southeastern part of Charlotte County is in the Caloosahatchee River watershed.

- Mean Net Primary Production

  Net primary production is the energy or dry organic matter remaining at the end of one annual cycle of growth after the plants' needs for metabolism have been met (Woodwell 1977); this is the energy available to support animal populations and includes harvest by man. Although actual amounts vary somewhat with local conditions, estimates of world net primary productivity of terrestrial ecosystems are useful in

Table 2.3. Importance Rankings of Terrestrial Habitat Types

	Habitat Type*	Number of Vertebrate Species and Number by Special Category Associated with Each Type, with Abundance Ratings at Level II**				Vulnerability***	Endanger-ment***	Priority+	World Mean Net Primary Productivity (gm/m^2/yr of dry organic matter)‡
		Terrestrial Vertebrates	Threatened and Endangered	Commercial and Recreational	Ecologically Significant				
Uplands	Mixed forest (pine-oak)	155: 6A, 48C, 62U, 39R	11: 0A, 4C, 5U 2R	10: 0A, 0C, 7U, 3R	28: 2A, 9C, 10U, 6R				
	Sandhills	155	11	9	27	Moderate	High	2P, K	
	Scrub	128	10	9	22	Moderate	High	1K	
	Deciduous forest (hammocks)	174: 2A, 36C 65U, 71R	4: 0A, 0C 2U, 2R	10: 0A, 0C, 10U, 0R	30: 1A, 8C, 13U, 8R	Low	High	1P, 2C	1,200
	Cabbage palm	132	2	6	17				
	Mesic	158	3	9	23				
	Live Oak	152	2	8	21				
	Evergreen forest (pine flatwoods)	163: 17A, 41C 68U, 56R	15: 0A, 0C, 7U, 8R	15: 2A, 3C, 5U, 5R	37: 4A, 10C, 14U, 8R	Low	Low		
	Scrub	134	10	10	25				1,300
	Typical	170	12	15	36				
	Herbaceous Rangeland (dry prairie)	100: 15A, 24C, 37U, 24R	5: 0A, 0C 2U, 1R	14: 2A, 3C, 6U, 3R	16: 2A, 8C, 1U, 5R	Low	High	1K, C; 2P	900
	Mixed rangeland (dry brushland)	88: 1A, 26C, 35U, 26R	1: 0A, 0C, 1U, 0R	10: 0A, 3C, 6U, 1R	16: 0A, 7C, 7U, 2R	Not rated	Not rated		
	Orchards, groves, etc.	110: 6A, 44C, 33U 27R	2: 0A, 1C, 1U, 0R	8: 0A, 5C, 2U 1R	17: 1A, 8C, 5U, 2R	Not rated	Not rated		
	Plantations	43	0	5	11				
	Parklands	75	2	7	17				
	Old field	74: 6A, 27C, 21U, 20R	3: 0A, 0C 2U, 1R	7: 0A, 3C, 4U, 0R	15: 0A, 9C, 3U, 3R	Not rated	Not rated		
	Cropland and pastures	67: 7A, 31C, 18U, 11R	4: 0A, 0C 2U, 2R	8: 0A, 3C, 3U, 2R	14: 1A, 7C 3U, 3R	Not rated	Not rated		
	Cropland	43	3	6	10				650
	Pasture	63	4	8	14				600
Wetlands	Forested wetlands	253: 2A, 50C, 85U, 114R	13: 0A, 4C, 3U, 6R	19: 1A, 5C, 7U, 6R	46: 0A, 8C 20U, 18R				
	Bayhead forest	133	4	3	20	Not rated	Not rated		
	Mixed hardwood swamp	220	6	14	43	High	High	1P, C, 2K	
	Cypress swamp	201	6	15	35	Moderate to high	Low	1P, 2C	
	Mangrove swamp	33	8	3	5	Moderate	Moderate		
	Brushland swamp	77	2	6	14	Not rated	Not rated		3,000 ‡
	Nonforested wetlands	169: 6A, 39C, 60U, 64R	10: 0A, 1C, 5U, 4R	28: 1A, 8C, 13U, 6R	35: 1A, 8C, 14U, 12R				
	Wet Prairie	136	9	22	31	High	High	1P, C, K	
	Freshwater marsh	130	8	21	23	High	High	2P, C, K	
	Saltwater marsh	37	5	6	8	Moderate	Moderate		

*LUDA Level-II and applicable Level-III vegetation cover.

**From Tables 5.2 and 5.3, Section 5, Volume VI, where A = abundant, C = common, U = uncommon, and R = rare.

***Florida Department of Natural Resources statewide assessment (1975).

+Determined by Florida Game and Fresh Water Fish Commission for Peace, Withlacooche, and Hillsborough river watershed (P), Kissimmee River watershed (K), and Caloosahatcheee River watershed (C) (DNR 1975).

‡Woodwell (1977).

‡Value given for "swamps and marshes."

a relative sense. For purposes of comparison, mean net primary production (expressed in grams per square meter per year) based on worldwide studies (Woodwell 1977) is used. The comparisons are considered applicable since, for example, available data indicate that net primary production in various Florida wetlands is above the 3,000 grams per square meter per year mean (TI 1977e:Volume V, Chapter 2, Section 2; TI 1977f: Volume VI, Section 5).

Yet another factor considered in evaluating the habitat types is uniqueness, which is of prime importance in terms of biogeographic and biosystematic value as well as aesthetic appeal. Unique biota is "atypical and limited in distribution to a particular area; it generally is not present elsewhere" (Lowman 1975). Best fitting uniqueness within the habitat types are two plant communities, the sand pine scrub and the dry (or palmetto) prairie. Except for a quite small area in southeast Alabama, the sand pine-scrub oak association is found only in Florida (DNR 1975). The palmetto prairie community is limited to Florida.

The order of importance of the habitat types also may be considered an indication of sensitivity to present or proposed phosphate development; the most important system or systems are the most sensitive, or least resistant, to the technological demand elements. To accommodate the different responses of wetland and upland habitat types to phosphate activities as well as to the scenario describing no mining or development of processing facilities in waters or wetlands of the U.S., they were regarded as two distinct environmental demand elements. This illuminates the obviously great and partially protected importance of wetlands and allows proper recognition and emphasis of important upland habitat types.

(i) Wetlands

Several kinds of wetlands, both saltwater and freshwater, comprise a significant portion of the 7-county study area. Although forested wetlands in general support a greater number of terrestrial vertebrates, including threatened and endangered and ecologically significant species,

functions of nonforested wetlands are equally important; thus, a determination of priority between the two types is impractical (Table 2.3).

Functions of wetlands (detailed in Section 5 of Volume VI and Chapter 2, Section 2, of Volume V) are:

- High-yield energy source - wetlands are generally the most productive ecosystems on earth and are of considerable economic value.
- Nutrient removal - phosphates and nitrates, which may cause eutrophication of water bodies, are processed.
- Waste treatment - wetlands are a natural filter system for sewage and waste water.
- Pollutant removal - heavy metals, particulates, and radioactive wastes are processed.
- Storm and wave buffering - runoff after rains is slowed, and energy from battering waves is absorbed.

Remaining natural wetlands of significant extent and value in the United States occur primarily in central and southern Florida and in southeastern Louisiana. According to the Florida Department of Natural Resources (1975), "from the standpoint of benefit to society, wetlands are probably Florida's most valuable natural systems."

(ii) Uplands

Among the various uplands habitat types, forested types (especially mixed and deciduous forests) are considered most important. The ranking of pine flatwoods, although the type is not considered endangered in the state, is consistent with its importance to the study area: its decline in the seven counties is substantial, with an additional 7.0 percent reduction from mining projected by the year 2000; it is the most important uplands habitat for threatened and endangered species as well as commercial and recreational species and ecologically significant species.

Unfortunately, the extent of mixed forest and deciduous forest in the seven counties is not readily apparent on the base land use land cover map. As pointed out in Volume III (TI 1977c), the LUDA maps employ a minimum-area recording size of 4 hectares (10 acres); a land use occupying less than that amount is not mapped as a distinct land use but is merged with an adjacent land use in the most logical manner possible. Inherently, forested hammocks generally cover small areas (TI 1977f: Volume VI, Section 5). Because of land cover fragmentation associated with development (including agriculture), remaining sandhills and sand pine scrub also occupy small, scattered areas. However, land use data presented in Developments of Regional Impacts (DRIs) of various phosphate companies (Borden 1968, W.R. Grace & Co. 1975, Beker Phosphate nd, Phillips Petroleum 1975, CF Mining 1973) document the presence of some rather large parcels (as much as 40 hectares, or 100 acres) of either mixed or deciduous forests that are not delineated on the LUDA maps. Possibly, these parcels are included among the evergreen forest extent on the LUDA maps. The DRIs describe even larger parcels of nonforested wetlands that are not delineated on the maps. A reconnaissance of the study area and a knowledge of vegetation types comprising a proposed industrial site and surroundings in DeSoto County confirm omissions. This is a decided data gap in the assessment of impact on these sensitive habitat types, and possibly on other habitat types as well. Although not within the scope of this study, a vegetation cover map derived from more recent and closer aerial photography, particularly of the mining district, would be most useful, if not necessary, in making assessments of specific locations. A common land cover nomenclature and categorization also is needed to ensure data compatibility and comparability. For example, areas that obviously are sand pine scrub or sandhills are sometimes called xeric hammock, which in most classifications is a live oak association. It is anticipated that the nationwide wetlands inventory to be conducted by the U.S. Fish and Wildlife Service will more clearly define wetlands habitats and their extent.

b) Demand Elements

Three areas of critical concern are applied to the habitat types:

- Areal extent
- Habitat quality
- Community structure

Included under areal extent are areal estimates of habitat types either destroyed or disturbed by the mining within the various scenarios (Table 2.2); although some of the land within each area is not mined, relatively little is undisturbed. The estimates were derived by overlaying the LUDA maps and consequently contain the deficiencies mentioned earlier. A partial listing of habitat-type acreages on pending mining areas indicates the magnitude of the deficiencies (Table 2.4). The severity of impact associated with areal extent was derived from the importance of the habitat type, the feasibility of its restoration, and the amount of habitat type mined or disturbed compared with the total amount of that type in the seven counties. The latter, although common practice in impact assessment, is often weak and not applicable to certain types since any encroachment upon endangered lands is significant.

Table 2.4. Vegetation Cover To Be Mined or Disturbed in Pending-Permits Areas*

Habitat Type	Hectares/Acres
Cropland and pasture	
Cropland and old field	202/5,000
Pasture	2,544/6,287
Plantations	
Slash pine	227/560
Citrus	162/400
Herbaceous rangelend	7,320/18,087**
Cabbage palm hammock	421/1,041
Live oak hammock	395/975+
Pine flatwoods	4,047/10,000
Sandhills and sand pine scrub	259/640
Forested wetlands	1,451/3,585
Nonforested wetlands	3,668/9,063

*Developments of Regional Impact (DRIs): CF Industries, Borden, W.R. Grace, Phillips, Beker, Mississippi Chemicals. Breakdown of additional 3,642 hectares (9,000 acres) comprising flatwoods, citrus, and mesic hammock not available.

**Probably includes some mixed rangeland.

+Plus small amount.

Consideration of habitat quality encompasses the effects on the quality of habitat adjacent, close, or remote to mining areas as well as that actually mined.

Community structure is the kind and abundance of species occurring in a habitat type.

Important biota also were considered demand elements. Among these groups, threatened and endangered species are of most concern, followed in order by commercial and recreational species, ecologically important species, and nuisance and pest species.

c) Effects on Terrestrial Biota

(i) Areal Extent

Within currently permitted mining areas, more than 2,995 hectares (7,400 acres) of freshwater wetlands habitat will be destroyed by 1985 and another approximately 2,145 hectares (5,300 acres) by 2000 (Table 2.2). The 5,140 hectares (12,700 acres) represent about 3 percent of the study area's wetlands acreage as of 1975 (TI 1977c:Volume III, Chapter 4, Table 2.1). The acreages are believed to be minimum values since substantial amounts of non-forested wetlands habitat, particularly wet prairies, apparently are not mapped.

There is no indication that true wetlands of any kind can be reclaimed on mined land. Not only is the low-relief, intricate topography of wetlands difficult to restore, but the deep, very poorly drained soils can neither be restructured nor feasibly conserved. Furthermore, the more clayey postmining soils are less acidic than those supporting some wetlands habitats (e.g., cypress swamps, bayhead forests). Since freshwater wetlands cannot presently be reclaimed and there is little chance of developing feasible restoration methods in the forseeable future, and since wetlands are the most productive ecosystems in the study area, mining them constitutes an irreversible and irretrievable commitment of a valuable natural resource.

Of uplands habitat, approximately equal amounts of a total of 21,044 hectares (52,000 acres) will be mined by 1985 and between 1986 and 2000 in currently permitted areas. Total uplands/wetlands habitat to be mined by 2000 approximates 26,225 hectares (64,800 acres); of this, more than 8,094 hectares (20,000 acres) will be converted to lakes. The areal extent of habitat types that will be restored on the remaining land is unknown. For various reasons (including irreversible effects of mining, reclamation regulations and state of the art, and economics) improved pasture is the predominant type; smaller extents of parkland, plantations, and croplands are expected. There is some question as to why additional acreages of pine plantation are not included in reclamation. One source (letter from Agrico to BLM, pages lx-135, Osceola EIS, USDI 1974) indicates that plantations are limited because of a 12- to 15-year growth period before harvest and economic return; another source (Borden 1975), however, indicates that pine plantation, as well as orange plantation, is only fairly successful on mined land. Although perhaps no more productive in terms of life support than pasture, interspersed pine plantation would be helpful in terms of diversity.

Regardless of reclamation practices, forest and rangeland habitat types will not readily reestablish in their native condition on mined land. The soils necessary for sandhills and sand pine scrub communities are, like the soils of wetlands, irreversibly altered. The result is the permanent loss of these important communities. Because the well-drained sands supporting these communities are low in organic content and considered infertile, the postmining soils replacing them often are claimed to be an improvement (Beker Phosphate nd). Were the mined land allowed to naturally revegetate, there might eventually be greater productivity in terms of life support. The argument, however, obscures the uniqueness of the vegetation and associated fauna and the fact that the sclerophyllous plants characterizing this native type support a greater variety of wildlife than either natural nonforested upland habitat types or the various agricultural habitats of reclaimed areas. The areal extent of mixed forest to be mined is unknown.

Long-abandoned mining areas develop into a habitat type similar to deciduous forest or hammock. Some characteristic plants of hammocks (e.g., palms) do not readily reestablish, and the hammock configuration - islands of vegetation 0.3 to 0.5 meters (1.0 to 1.5 feet) above surrounding pinewoods - is destroyed. Greatest impacts associated with destruction of typical hammocks are further reduction in the small remaining extent of these geographically restricted climax types (the remaining significant extent in the study area is in southwestern Polk County), the amount of time necessary for reestablishment of similar types, and, importantly but most mitigatable, the reclamation requirements that generally preclude natural revegetation.

Loss of an underlying organic hardpan during mining precludes the reestablishment of certain associations (e.g., longleaf pine-saw palmetto-wiregrasses-heath shrubs) within rangeland and evergreen forest habitat types. By the year 2000, approximately 7 percent of the areawide acreage of evergreen forest will be mined, representing 52 percent of the projected areawide reduction of evergreen forest by that time (Table 2.5). A considerably smaller percent of the areawide extent of rangeland will be mined; nevertheless, it will represent 39 percent of the areawide change by 2000. The greatest impact associated with destruction of rangeland will be mining in areas that are truly dry prairies, the second-ranked priority lands in the study area's primary watershed. Available data do not permit a distinction between dry prairie and rangeland that has been shaped from deforestation, so the extent of dry prairie, if any, in the mining area is unknown. Most of the large extents in the seven counties are in Polk County east of the present mining area and in DeSoto and Charlotte counties east and south of potential mining areas (DNR 1975). Smaller extents are in Sarasota and Manatee counties; that in the southernmost extension of Manatee County is close to, if not part of, land projected for mining. Once removed, wiregrasses, which are among the dominant grasses in the prairies, apparently will not reestablish for 100 years, if ever (DNR 1975).

Approximately two-fifths (8,661 hectares or 21,400 acres) of uplands habitat to be mined in permitted areas by 2000 is agricultural, primarily improved pasture; this represents about 3 percent of present areawide

Table 2.5. Short-Term and Long-Term Areawide Percent Changes in Habitat Types under Scenarios 2.15 and 2.11

	(2.15) "Without Action" Alternative						(2.11) Mining of Permitted and Pending-Permit Areas					
Habitat Type (Level-1, USGS)	1985 Adjusted Acreage*	Hectares/Acres Mined	% Areawide Change 1975-85 Due to Mining	2000 Adjusted Acreage*	Hectares/Acres Mined	% Areawide Change Due to Mining	1985 Adjusted Acreage*	Hectares/Acres Mined	% Areawide Change Due to Mining	2000 Adjusted Acreage	Hectares/Acres Mined	% Areawide Change Due to Mining
Cropland, pasture	300,230/741,053	3,807/9,408	19	304,059/751,320	8,651/21,376	53	295,568/730,339	7,175/17,728	29	299,397/739,800	17,846/44,096	85
Orchards, groves	130,401/322,217	130/320	2	127,509/315,070	907/2,240	10	130,276/321,907	155/384	3	127,383/314,760	1,347/3,328	15
Rangeland	436,507/1,078,593	3,833/9,472	25	434,460/1,073,535	6,682/16,512	39	424,333/1,048,513	6,657/16,448	24	422,286/1,043,455	8,260/45,120	62
Forest (primarily evergreen)	56,568/139,778	3,056/7,552	23	60,258/148,895	4,843/11,968	52	55,095/136,138	4,041/9,984	27	58,784/145,255	7,459/18,432	69
Wetlands	**											

*U.S. Corps of Engineers Four River Basins Study (1976).

**Change in areawide wetlands areal extent cannot be treated since projected acreages are unrealistically high. More hectares (2,995 or 7,400 acres) will be mined by 1985 in permitted areas alone than the projected loss (2,024 hectares or 5,000 acres) by then for the entire study area (see Table 2.1 in Volume X). Since projections assume mining of pending-permit areas as well (see Land Use in this paper), a more realistic decline in wetlands areal extent by 1985 would be at least 4,856 hectares (12,000 acres).

agricultural land. Although obvious effects are associated with removal of habitat, agricultural displacement essentially can be considered temporary and of little areawide impact. Grasses successfully planted on reclaimed land (e.g., bahia grass) are similar to those currently used for improved pasture on unmined land.

Habitat types that can develop on mined land basically are those associated with the mining pits (water bodies formed from cutting into the shallow aquifer) and those associated with slime ponds, which comprise another 30-35 percent of mined land. Primarily because of erosion, vegetation on spoil banks above the mining pits apparently remains patchy for several years. Approximately 7-8 years after mining, herbaceous and shrub (e.g., grasses and groundsel) vegetation covers from half to most of the spoil-bank surface, depending on the bank's slope, with cattail establishing along the edge of the water and grasses (e.g., broomsedge) establishing rather uniformly in more level areas among the spoil banks. Conditions generally are advanced old field. In 25-30 years, a young hardwood association (e.g., red maple-black cherry) may develop. Slime ponds are invaded by cattail, which remains for several years while wet-site vegetation (e.g., willow) develops on the banks. In approximately 20 years, grasses (e.g., broomsedge) replace the cattail and additional woody vegetation (e.g., wax myrtle, oaks) establishes around the dewatered slime area. Unlike marshes or other wetlands, these areas are essentially closed ecosystems and, as the name indicates, are more correctly considered ponds. These artificial "marshes" will succeed more rapidly to a mesic community than natural wetlands. The primary effect of slime placement on areal extent is the time lag in the development of terrestrial habitat. With approximately 30 percent of mined land left covered with water and an equal amount covered with slime, only about one-third of the mined area can become terrestrial habitat soon after mining. Current reclamation procedures can speed up slime dewatering and make the areas suitable for pasture (and probably more preferably habitat as well) within approximately 6-8 years after final deposition of slime.

(ii) Habitat Quality

That the quality of terrestrial habitat generally reclaimed in mined areas is inferior is readily apparent when comparing wildlife usage of agricultural land with that of natural systems (Table 2.2 in this text and TI 1977f:Volume VI, Table 5.3).

Habitat that is not mined also is affected by various activities of the industry. For the most part, the effects are limited to habitat adjacent to or near that being mined. Inhabitants of both wetlands and uplands may be stressed by noise, dust, emissions, and removal of adjacent habitat. Wetlands biota, particularly, may be stressed by surface- and groundwater changes. Quantification of impacts associated with these effects are problematic, even when field studies are done. When several effects are occurring at once, it is difficult to separate either the effects or tolerance levels. Generally, when two or more are operating together, tolerance limits of all are reduced (Darnell et al 1976). Sources of greatest noise in the mining areas apparently are beneficiation, drymills, and draglines, especially the latter (W.R. Grace & Co. 1975); noise from the dragline is short-term rather than long-term, and affects various habitats at various times in various intensities. Susceptibility and response to noise vary among species and individuals; for most, effects thresholds are unknown. Among the possible effects are disruption of activity because of fright, interference of mating and alarm calls, and physiological disturbance associated with endocrine response to stress (Memphis State University 1971). Draglining (particularly when removing overburden) also stirs up the greatest amount of fugitive dust (W.R. Grace & Co. 1975). The amount of dust produced by draglining, as well as by clearing and construction of dams and levees, varies, peaking during the dry season. Neither vegetation nor fauna are harmed by dust that is soon removed by rain, but a persistent dust cover may limit the potential of vegetation as a habitat and cause minimal stress to plants. Some animals may avoid locations of heavy fallout.

Although emissions from rotary kiln dryers are now better controlled, the drying process may increase both background radiation and ambient particulate concentration (USEPA 1977). The effects of the

radiation on wildlife are unknown; but particulate fluoride uptake by certain forage plants has been observed and subsequent injury to cattle documented. There is either little incidence of fluorosis now, or that occurring is not reported. Evidence of fluoride in wildlife has recently been investigated by the science staff of the Florida Audubon Society, however, these data have not been made available for evaluation by TI.

Clearing land prior to mining produces effects other than dust and noise. The remaining habitat experiences nutrient loss, reducing the food supply of wide-ranging herbivores (e.g., deer) and carnivores (e.g., bobcat). Trails may be interrupted or parts of territories removed. Many fauna escaping the cleared area will enter the remaining habitat, resulting in greater competition for food, space, and mates in the remaining habitat. Each population that is beyond ecological limits will eventually decline to the level supportable by the remaining habitat. The carrying capacity for certain species is likely to be reduced by fragmentation.

Constructing dams to impound adjacent wetlands while draining those to be mined interrupts circulation and drainage patterns through the remaining wetlands. The modified flow rates alter nutrient flow, turbidity, and oxygen level. Part of the edge habitat, which comprises important transitional vegetation that is the primary site of sediment and nutrient filtration, is lost to the system through fragmentation. Although erosion apparently is largely contained, clearing and particularly mining increase the sediment load in streams. Downstream wetlands receive part of the sediment load, resulting in increased turbidity and sedimentation. Mining into the shallow aquifer decreases soil moisture or standing water in adjacent habitat within 330 meters (1,000 feet) for 3 to 6 months or, at most, a year (CF Mining 1973, W.R. Grace & Co. 1975). Effects are reported minimal, but vegetation damage is possible, depending on the species and time of year. Most plants are stressed more by moisture loss in summer, which is the wet season. Certain faunal species (e.g., amphibians in early spring) may be stressed by moisture loss also, with competition for available moisture increasing. Greater effects are possible in shallow wetlands than in uplands habitats.

Major environmental pollutants released during manufacturing are sulfur dioxide, suspended particulates, and gaseous fluorides. Although emission control devices apparently keep the ambient levels of these and minor contaminants within acceptable state and federal air quality levels, habitat quality is not enhanced by the emission standards or other standards, nor are optimum conditions ensured; habitat quality is allowed to degrade to tolerance limits of both industry and the environment in an effort to ensure the survival of both. Gaseous fluorides, like particulate fluorides, may be assimilated by plants and affect foragers. Sulfur dioxide is known to affect plants, with susceptibility and response varying with the species.

Most forms of reclamation will partially mitigate some of the effects of fragmentation by providing various amounts of cover and food for resident and migratory species and restoring edge habitat. Removing slurry pipelines and other transport systems will eliminate barriers. However, besides being of lower quality in terms of life support, reclamation (when it consists solely of obtaining vegetation cover) adversely affects environmental quality because of the application of fertilizers and pesticides. Use of these chemicals is widespread in croplands of the area; also, fertilizers and occasionally pesticides apparently are applied to accomplish pasture reclamation.

(iii) Community Structure

As indicated previously, natural revegetation would restore habitat that is of greater value to surrounding ecosystems. The fact that mining and subsequent reclamation are producing a more uniform habitat has certain implications relative to community structure in the region. Species diversity is higher in areas containing several vegetation types (DOT 1975), each supporting its peculiar assemblage of plants and animals and the common edge, or ecotone, supporting a greater variety than either adjacent habitat type alone. Especially is wildlife carrying capacity improved by the juxtaposition of vegetation types. As the number of vegetation types (landscape-pattern diversity) increases in an area, so does the number of plant and animal species.

The habitat types showing the greatest decline in the regional landscape are those of greatest individual diversity. The diversity within these types represents a greater variety of interactions among components (expanded food webs) and biological controls that tend to preserve an equilibrium. Various populations are less abundant in the more diverse habitat types: of the 67 vertebrate species reported in cropland and pasture (Table 2.3), 31, or nearly half, are common; less than one fourth of the 183 species reported in pine flatwoods are common. To maintain agricultural habitat types as such, it generally is necessary to use external controls such as pesticides to check populations. Croplands and other monocultures, which generally comprise much of the reclaimed land not in pasture, are the least diverse communities and the most expensive to maintain. Irrigation is one of the most costly attempts by man to maintain monocultures (Bishop et al 1974).

The immediate result of mining is an overall reduction in the populations of all species present. In addition to the destruction of vegetation, most fauna present on the sites are destroyed. Populations of fauna escaping into remaining habitat decline also, since predation and other controls intensified by crowded conditions prevail. Certain species recover and possibly proliferate on reclaimed land or in the early successional and less diverse habitat types that develop on unreclaimed land and slime ponds; these species generally are those associated with agricultural habitat and ruderal areas such as old field (TI 1977f:Volume VI, Table 5.3). Some species, as indicated earlier, are permanently excluded from the mining sites because of alterations in the physical environment - and elimination of certain species because of physical alteration disrupts the food chain, leading to the exclusion of other species. Many of the species that will permanently decline are those restricted to wetlands and mixed forest habitat types. A decline in diversity already noted in past and current mining areas apparently is attributable mostly to loss of wetlands habitats (Mehrhoff 1977).

Man-made lakes replacing part of the uplands/wetlands habitat are not expected to support the variety of terrestrial species associated with

the study area's natural ponds and lakes, or even the older slime ponds, but apparently will support a greater variety of species (primarily birds) than agricultural habitat. Still, none of the current forms of reclamation provide the variety of habitat necessary to support the diversity of the undisturbed landscape, so the uniform habitat that admittedly temporarily decreases aesthetic appeal (Borden 1970) permanently decreases diversity. These managed systems' life-support values (productivity) also are considerably less than those of the original habitats.

One of the more likely adverse effects on community structure in the study area is the establishment of undesirable exotic biota in disturbed areas. Certain of these species (e.g., Australian pine) can outcompete native species and become dominant in the community. Some exotics (e.g., pasture grasses and forbs) now support native fauna (particularly insects), but others are of little value. The deliberate introduction of woody species particularly [e.g., Eucalyptus (CF Mining 1973)] during reclamation is not beneficial.

(iv) Threatened and Endangered Species

Mining is likely to affect significantly 12 threatened and endangered terrestrial vertebrates (Table 2.6). Six others may be adversely affected, although their presence in the mining areas is doubtful. Any adverse effects on two species, the Osprey and Caracara, probably will be short-term, and the Osprey may benefit in the long-term. Two species, the Least Tern and Peregrine Falcon, both primarily coastal inhabitants, may be attracted to the mining areas. This is an outside possibility for the very rare falcon, which has been reported utilizing old mining areas but apparently was last seen in the study area (and state perhaps) 3 years ago (Layne et al 1977); the Least Tern, however, is locally common inland and is known to nest in suitable habitat (barren sites) in mining areas.

The primary threat that mining poses for most of the adversely affected species is habitat loss. Neither reclamation nor natural revegetation can restore for 25 to 30 years the riparian habitat used by the Bald

Table 2.6. Threatened and Endangered Vertebrates* Affected by Mining Activities

	Fauna	Major Threat	Habitat (primary and secondary if applicable)	Range in Florida
Most Likely To Be Adversely Affected	Florida Gopher Frog	Habitat loss	Sandhills Sand pine scrub (gopher tortoise dens)	Parks of panhandle and peninusla
	Gopher Tortoise	Habitat loss	Sandhills Pine flatwoods	Most of pandandle and peninsula
	Sand Skink	Habitat loss	Sand pine scrub Sandhills	Marion County south to Highlands County
	Eastern Indigo Snake	Habitat loss	Pine flatwoods Other forests and prairies (gopher tortoise dens)	Most of state
	Short-tailed Snake	Habitat loss	Sandhills Sand pine scrub, pine flatwoods	Peninsula north of DeSoto County
	Wood Stork	Food availability	Wetlands	Wide; colonies local
	Florida Scrub Jay	Habitat loss	Sandhills, sand pine scrub	Middle of peninsula
	Florida Sandhill Crane	Habitat loss	Prairies Old fields, low pastures, pine flatwoods	Most of peninsula; local in north Florida
	Bald Eagle	Habitat loss	Riparian	Wide
	Florida Mouse	Habitat loss	Sand pine scrub Other forests	Northern two-thirds of peninsula
	Sherman's Fox Squirrel	Habitat loss	Pine flatwoods Other forests	Northern two-thirds of peninsula
	Southeastern American Kestrel	Habitat loss	Pine flatwoods	Statewide except southern tip
May Be Adversely Affected	Blue-tailed Mole Skink	Apparently restricted to Lake Wales Ridge		
	Short-tailed Hawk	Presence in study area infrequent		
	Ivory-billed Woodpecker	Probably extinct		
	Florida Panther	Presence in mining areas doubtful		
	Florida Black Bear	Presence in mining areas doubtful		
	Red-cockaded Woodpecker	Nearest sightings somewhat east of mining areas in Polk, Hardee, and DeSoto counties; habitat restrictive		
Adverse Effects Marginal and Short-Term	Osprey	Presence in old mining areas frequent; will utilize modified habitats		
	Caracara	Presence in mining areas infrequent; will utilize modified habitats		

*Determined by USDI and FGFWFC.

Eagle, Osprey, and Short-tailed Hawk. The Osprey and the Bald Eagle are known to utilize long-abandoned mining areas that have revegetated naturally and are now wildlife sanctuaries. The Osprey, which will more readily inhabit areas of moderate human activity, may utilize the small amount of wooded areas proposed for reclamation around lakes where its food (fish) is plentiful. Opportunities on reclaimed land will be limited for both the Bald Eagle, which is less tolerant of human activity near its nesting site, and the Short-tailed Hawk, which does not hunt over improved pasture (FCREPA 1976). The Short-tailed Hawk apparently is an infrequent visitor in the study area and is not known to nest there. Active eagle nests are comparatively dense in Polk County, but none are reported on lands to be mined, although there are a few in the immediate areas. The eagle has been reported over proposed mining areas, however (Phillips Petroleum 1975).

There are known concentrations of the Caracara in proximity to proposed mining areas in Hardee and DeSoto counties. This raptor is more closely associated with open areas than with dense woodland habitat and will utilize improved pastures. Extensive areas of dry prairie apparently are preferred habitat (FCREPA 1976), and the bird was recently sighted near such habitat in a proposed mining area (Phillips Petroleum 1975). However, as mentioned previously, known extents of true dry prairies are limited, if occurring on present or proposed mining sites; thus, the probability of disturbing resident Caracaras is small.

The Florida Scrub Jay, Florida mouse, Florida gopher frog, gopher tortoise, sand skink, eastern indigo snake, and short-tailed snake probably will suffer population loss in the study area as their habitats are mined and individuals destroyed and, with the possible exception of the eastern indigo snake, are not expected to recover since habitats will not or cannot be restored. Recovery of the indigo snake, which occurs in a wider variety of habitats, is possible but doubtful since it generally avoids highly modified areas. The blue-tailed mole skink, which is apparently restricted to habitat (primarily sand pine scrub) along the Lake Wales Ridge, is less likely to be affected. All of these species except the sand skink, short-tailed snake, and blue-tailed mole skink have been reported from proposed

mining areas - and the three species not reported could have been easily overlooked during cursory surveys because of their obscure subsurface habitats.

The Florida Sandhill Crane, although inhabiting several types of grassy areas, would not be expected to occupy most reclaimed areas. This subspecies usually nests in low, seasonally wet areas; well-drained rolling pastures of reclaimed areas will not be suitable habitat. Distinguishing this permanent resident from the wintering Greater Sandhill Crane is difficult in the field. Generally, the Florida race occurs in pairs or family groups of three to four individuals; greater sandhills tend to flock, with the Florida sandhills sometimes joining the flocks. Pairs or small family groups present in summer or early fall can be assumed to be Florida sandhills. Apparently, the bird can be removed rather easily from areas to be disturbed and placed in other suitable habitat, and most transplants are successful since the essentially sedentary bird rarely attempts to return home (FCREPA 1976). In the absence of proper management, however, displacement by mining would mean population decline since the bird itself is not likely to move to new nesting habitat. It is the prevalent subspecies in the study area and occurs on at least two proposed mining sites (Beker Phosphate nd, W.R. Grace & Co. 1975).

The Southeastern American Kestrel also is a resident subspecies that is difficult to distinguish from a wintering subspecies, the Eastern American Kestrel. A substantial proportion of the southern Florida population of the seriously declining Southeastern American Kestrel is believed to be in the study area, particularly in an area comprising eastern Manatee and western Hardee counties (Layne et al 1977). Although during winter the bird utilizes a variety of habitat (including pasture and cropland), it shifts during the breeding season into open pinewoods where it nests in pine stubs; nesting may occasionally occur on man-made structures and in artificial nest boxes. The Southeastern American Kestrel apparently has nearly disappeared from the Lakeland-Bartow area, and further decline is expected as more pine flatwoods are removed by mining. Kestrels sighted in the study area during

June-August generally are assumed to be the southeastern subspecies since the eastern subspecies arrives in September and departs in May.

The Wood Stork feeds in areas similar to those inhabitated by the Florida Sandhill Crane but roosts in forested wetlands. Although none of the three breeding colonies reported in the mining area are on land to be mined, they probably utilize suitable feeding sites on these lands. The bird has been reported frequenting proposed mining areas (Phillips Petroleum 1975, Borden 1973). Colonies move from place to place, heading as the dry season approaches to areas that have permanent shallow waters. Small fish in creeks, ponds, pools, and marshes comprise the stork's diet, and suitable feeding sites, like nesting sites for the Florida Sandhill Crane, are expected to be rare in reclaimed areas.

Sherman's fox squirrel generally declines in its preferred longleaf pine/turkey oak habitat as the longleaf pine is logged. Apparently, most of the flatwoods and other forests to be mined are already modified and the squirrel is as scarce in the mining area as on most lands other than those on which wildlife is managed. Sherman's fox squirrel occurs on at least two proposed mining sites (W.R. Grace & Co. 1975, Phillips Petroleum 1975). Further population decline is expected to result from mining activities, and reclaimed areas will offer little if any opportunity for the species. Although its threatened status is designated by the FGFWFC, hunting regulations allow a daily take of two individuals. There seems to be some contradiction in the commission's regulation and its edict that it is unlawful to take any threatened or endangered species. It is generally conceded, however, that habitat loss rather than hunting pressure causes population decline.

The Red-cockaded Woodpecker is associated even more so than Sherman's fox squirrel with mature to overmature pines in rather open canopy. Longleaf pine is most often used as a nesting site, and slash pine is sometimes used (FCREPA 1976); generally, the trees that are used have heart rot. In the study area, there are known colonies in Hardee County to the east of the areas to be mined; but the bird has not been reported from

mining areas and seems unlikely to occur there since overmature slash and longleaf pines apparently are scarce.

Neither the Florida black bear (an estimated 500 individuals in the state) nor the Florida panther (an estimated 100 to 200 individuals in the state) is known to have den sites on lands to be mined; both, however, may range over present or proposed mining areas, particularly those in the southernmost extension of Manatee County (Layne et al 1977). The bear also may range over mining areas in Hardee County and the panther over the more northern mining areas in Manatee County. Mining forests, particularly swamp forests, could reduce the carrying capacity of both species.

Several proposed (Smithsonian Institution 1975) threatened and endangered plant species other than those listed in Section 5 of Volume VI (TI 1977f) occur in the study area (Shuey 1977):

Butterfly pea (Centrosema arenicola)
Blazing star (Liatris ohlingerae)
Bear grass (Nolina brittoniana)
Hand fern (Ophioglossum palmatum)
Whitlow-wort (Paronychia chartacea)
Jointweed (Polygonella myriophylla)
Nodding cap (Triphora latifolia)
Vervain (Verbena maritima)
Coontie palm [Zamia integrifolia (floridana)]
Warea cartei
Hartwrightia floridana
Rhapidophyllum hystrix

Two species - butterfly pea and coontie - have been reported in pine flatwoods habitat in proposed mining areas. As is the case with other restricted components of typical flatwoods, these plants are not likely to reestablish on mined land.

Mining activities will adversely affect several faunal species considered to be either rare or of special concern by the Florida Committee on Rare and Endangered Plants and Animals (1976) or blue-listed by the journal American Birds (TI 1977f:Volume VI, Table 5.2). Loss of wetlands will reduce favored habitat of Black- and Yellow-crowned Night herons, American and Least bitterns, and King Rail. The Little Blue and Louisiana herons, White Ibis, and Great and Snowy egrets will be similarly affected, particularly if the shallow mining pits which they currently use are reclaimed to steep-sided lakes. Loss of either upland or wetland forests, or both as the case may be, will reduce habitat of the Red-headed and Hairy woodpeckers, Yellow-billed Cuckoo, Louisiana Waterthrush, American Redstart, Bachman's Sparrow, and Florida scrub lizard. It is difficult to assess adverse effects, if any, on several other species in these categories, since their status or distribution in the mining area is uncertain or precise factors contributing to their decline are unknown. Among such species are the southeastern shrew, hoary and big brown bats, Cooper's Hawk, and White-breasted Nuthatch. The Double-crested Cormorant, Barn Owl, Florida Burrowing Owl, Common Nighthawk, Purple Martin, Vesper Sparrow, and Florida long-tailed weasel are among the comparatively few species in these categories that probably will find adequate opportunities on reclaimed land.

(v) Commercial and Recreational Species

Less than half of the migratory duck species entering Florida overwinter in large numbers as far south as the study area. The southernmost point of most duck migration in Florida is an east-west line along Lake Okeechobee, but numbers of migrants stop before reaching the area. Mining of inland wetlands will reduce habitat of several of those migrants entering the study area. Lakes and ponds resulting from mining activities, however, are used to various degrees by inland migrants and therefore can be considered of value to them (in a few instances, of great value). Occasionally, these water bodies also are used by species uncommon or rare in the area (e.g., Gadwall, Pintail). Common species (e.g., Ring-necked Duck, Blue-winged Teal) most often use them, however - and among the common species, the most constant users are divers, which are able to feed in the steep-sided, moderately deep water bodies (Table 2.7). Additional habitat created by mining

is not expected to increase significantly the number of migrants using the region, although migrant usage may shift from existing locales in and near the study area to the mining areas.

Table 2.7. Expected Waterfowl Usage of Aquatic Habitats in 7-County Study Area

Common Name	Reclaimed Lakes	Shallow Ponds and Shallow Mining Pits	Other Water Bodies	Streams	Forested Wetlands	Non-forested Wetlands
Canada Goose	L*		L			
Mallard	L	M*	M	L	L	M
Black Duck	L	L	M	L	M	M
Mottled Duck	L	M	M	L	L	H*
Pintail	L	M	M	L	L	M
Gadwall	L	L	M	L	L	M
American Wigeon	L	L	M	L	L	H
Northern Shoveler	L		M			M
Blue-winged Teal	L	H	M	L	L	M
Green-winged Teal	L	M	M	L	L	M
Wood Duck	L	L	M	M	H	M
Redhead	L		M			
Ring-necked Duck	H	M	H	L	L	L
Canvasback	L		L			
Lesser Scaup	M		M			
Bufflehead			L			
Ruddy Duck	M	L	M			
Hooded Merganser	L	M	M	L	H	M
Red-breasted Merganser			L			
American Coot	M	M	H	L	L	M

*L - light
M - moderate
H - heavy

The Mottled Duck and the Wood Duck, which are common residents in the study area, are not expected to be heavy users of the water bodies; indeed, local numbers of these primarily marsh and woodland species may diminish as wetlands are mined.

Appearing to utilize the mining area water bodies almost as heavily as others in the study area are the American Coot, a common winter resident in the study area, and the Common Gallinule, a common permanent resident. The Common Snipe, a common winter resident that feeds along the shore zone, is known to use the shallower mine pits, but reclamation of the pits as well as mining of shallow marshes (a favored habitat) generally will be

detrimental to the bird. The Sora, a rail that is a common winter resident, will be similarly affected. Other rails, all rare to uncommon inland in the study area, will be adversely affected by the removal of marsh habitat.

Migratory geese rarely enter the study area. In Florida, migration of the Canada Goose is concentrated in the northwestern coastal bend, and quite small numbers of the Snow Goose may enter the same general area although the state is east of this species' important migratory corridors (Bellrose 1968). Domesticated geese, however, are common on man-made lakes in the study area, so mining area lakes and ponds are potential habitat for these residents as well as for the Mallard, which is an uncommon migrant but comprises a large portion of domestic waterfowl.

Overall, hunting potential of waterfowl (ducks, coots, geese) will be increased in the mining area as long as shallower mining pits and slime ponds are available. However, these species comprise only a small percentage (less than 10 percent) of Florida's game bag, and a comparatively small percentage of hunter effort is directed toward them (Harris and Glynn 1976); in fact, approximately 75 percent of hunter effort, which is somewhat greater in northwestern Florida but otherwise rather equally distributed over the state, is directed toward only five game species: deer, squirrel, dove, quail, and wild hog.

Removal of rangeland and forest habitat will adversely affect a currently declining Turkey population. The recreational potential of this species on most private land has already diminished because of habitat loss, and Turkey hunting primarily occurs in wildlife management areas. Both the Bobwhite and the Mourning Dove, which comprise approximately 40 and 20 percent respectively of Florida's game bag, are often hunted in other than managed areas. The Bobwhite is a common inhabitant of woodland/rangeland ecotones in the study area, and the Mourning Dove is a common inhabitant (permanent resident as well as migrant) of agricultural areas and rangelands. The recreational potential of quail in most reclaimed areas probably will be reduced somewhat from its current level, whereas that of the dove will not be affected and may be increased. Both species are common in

abandoned, unreclaimed mining areas, but the Mourning Dove is expected to utilize improved pastures of reclaimed land more than will the Bobwhite.

The trapping potential of fur-bearers and the hunting potential of game mammals will be variously affected by mining activities. The hunting potential of common species with less specific food or habitat requirements (e.g., raccoon, eastern cottontail rabbit, opossum, eastern spotted skunk) will be little affected, while that of most wide-ranging carnivores (e.g., bobcat, gray fox) will be moderately affected. Of significance is reduction of squirrel habitat (woodlands) and food (acorns, cypress and pine seeds), since these mammals represent about 13 percent of hunter effort and apparently are widely hunted on private lands. Loss of white-tailed deer and wild hog habitat, although reducing local populations, probably will not affect the recreational potential of the species: they are more often hunted in wildlife management areas and, unlike the Turkey, are not experiencing population declines.

Largely because of state and federal game management, mining is not expected to have a significant effect on overall abundnce of game in the region; however, because land use changes rather than hunting pressure generally determine what species comprise the game list, it potentially can affect the quality of hunting. Florida's game list has dwindled and may diminish even farther (Harris and Glynn 1976). More immediately, mining will contribute to the increasing cost of maintaining huntable populations: as development continues, game management must be intensified and more land purchased or leased by the state. Currently, the hunting region encompassing the study area (the south region) has the smallest wildlife management area in the state.

(vi) Ecologically Significant Species

Although mining probably will not seriously affect many of the approximately 75 ecologically significant species in the study area (TI 1977f: Volume VI, Table 5.3), it is expected to diminish opportunities for as many as three-fifths of them.

Four ecologically significant amphibians (the giant toad; bronze, bull, and pig frogs; and Cuban treefrog) should utilize shallow mining pits or reclaimed water bodies. Species generally not associated with disturbed or modified habitats and not expected to occupy reclaimed areas include the lesser and dwarf sirens; the southern dusky, dwarf, and slimy salamanders; the eastern spadefoot toad; and the ornate chorus frog. The latter reaches the southern limits of its range near the northern edge of the study area and could occur in the mining area although not reported from there recently.

Two ecologically significant reptiles (the green anole and the Florida water snake) common in at least one habitat type in the mining area are known to frequent agricultural and other man-modified habitats. Likely to be affected adversely by removal of wetlands and forested uplands habitat are eight others (the fence and worm lizards; the striped swamp, Florida swamp, southern hognose, pine woods, and Florida crowned snakes; and the pygmy rattlesnake) that are known or believed to occur in the mining area. The rarest of these are apparently the pine woods snake (yellow-lipped snake), an inhabitant of most forest types, and the crowned snake, an inhabitant primarily of mixed forest; like the ornate chorus frog, these snakes reach the southern limits of their ranges in the study area.

Known to utilize shallow mining pits in which floral and faunal communities have developed (TI field reconnaissance) are several water-oriented, ecologically significant birds including the Great Blue Heron, Green Heron, Pied-billed Grebe, Glossy Ibis, and Belted Kingfisher. Converting the pits to comparatively deep, steep-sided water bodies would adversely affect the birds. The Cattle Egret, more frequently associated with terrestrial habitat than aquatic habitat, will find abundant opportunities on reclaimed land. Other land species that probably will hunt in the open country and croplands of reclaimed land include vultures as well as some hawks, particularly the Rough-legged, Marsh, and Red-tailed hawks. Most of these raptors, however, are closely associated with forest habitat, where they nest or roost. The Sharp-shinned Hawk and Red-shouldered Hawk, which apparently feed primarily in open woodlands in the study area as well as nest

there, are not expected to find adequate habitat in reclaimed areas. The Rough-legged Hawk, which only casually enters Florida during winter, is the least likely of these raptors to be found in the mining area.

Mining will diminish opportunities for the Great-horned and Barred owls, which are common only in forests of the study area. The Screech Owl, also a common woodland species in the study area, apparently will readily inhabit highly modified woodlands such as parks and plantations and may find adequate habitat in similar reclaimed areas. The Short-eared Owl, which inhabits wet and dry prairies as well as several types of modified habitat but is a rare winter visitor in the study area, is expected to occupy both disturbed and reclaimed mining areas.

Other primarily forest inhabitants that will be adversely affected are the Pileated Woodpecker, Eastern Bluebird, and Brown-headed Nuthatch. Habitat of the Brown-headed Nuthatch, which, like that of the Red-cockaded Woodpecker and White-breasted Nuthatch comprises mature to overmature pine woods, already has been so severely altered in the mining area that the bird may not be present there at all (Borden 1975).

Ecologically significant birds that will be adversely affected by removal of marshes and forested wetlands are the Limpkin, Yellow Rail, and Purple Gallinule. These species are rare in the study area and, although known to utilize modified habitats occasionally, are likely to become even rarer in the mining area due to loss of favored habitat.

The Loggerhead Shrike, Starling, House Sparrow, and Eastern American Kestrel should not be significantly affected, since all readily inhabit modified areas. Depending on the use of reclaimed land, the Starling and House Sparrow may proliferate (see Nuisance and Pest species).

Of the ecologically significant small mammals expected or known to occur in the mining area, the northern yellow bat (a rare inhabitant of mesic hammocks in the study area) as well as the short-tailed shrew, golden

mouse, and eastern woodrat (all uncommon forest inhabitants) will be significantly affected. The eastern harvest mouse, a generally rare inhabitant of herbaceous fields, probably will inhabit reclaimed areas. Also expected to utilize disturbed and reclaimed areas (although the frequency is uncertain) is the southeastern pocket gopher, which commonly inhabits dry prairies but is uncommon elsewhere. Of the larger ecologically significant mammals, only the nine-banded armadillo is expected to utilize mined land frequently. Habitat loss likely will affect the river otter (uncommon in the study area) and the bobcat (generally common in the area), both of which are being reviewed by the USDI to determine whether or not they should be placed on the threatened and endangered list.

Distribution maps of most of the important vertebrate species in the study area can be found in a report prepared by Archbold Biological Station (Layne et al 1977) for the U.S. Fish and Wildlife Service. Intended as an up-to-date fish and wildlife inventory of the 7-county region included in the central Florida phosphate industry areawide environmental impact study, the report contains comprehensive species accounts as well as assessments of the fish and wildlife values of various habitat including those of mined land.

(vii) Nuisance and Pest

Mining activities will increase the potential of several species to reach population levels of nuisance or pest proportions. As disturbed areas, urban areas, monoculture, and cattle become more prevalent, so will associated pest species. Mammals expected to proliferate include the black rat, Norway rat, and house mouse. Birds that will become more abundant include the Red-winged Blackbird, Starling, House Sparrow, and Cattle Egret. Insect pests will proliferate around the cattle, in areas devoted to monoculture, and in the nutrient-rich reclaimed lakes.

There is presently little problem in controlling nuisance and pest species, and none is expected in the future. Thus, the increased abundance of these species should have little regional impact. However, as in the

case of commercial and recreational species, costs of controlling the species will be greater; and in this case, further degradation of the environment will occur through the use of pesticides. In addition to the secondary effects of chemically contaminating the environment, pesticides directly kill nontarget organisms as well as pests.

c. Water

1) Water Quantity

The methodology with which the effects of the environmental demand elements included under physical and hydrological, elements 31 (surface water quantity), 33 (water-table aquifer quantity), 35 (Floridan aquifer quantity), 36 (aquifer recharge), 37 (erosion), 38 (flooding), and 39 (cavitation) were assessed for the "Without Action" alternative (Scenario 2.15) in the following paragraphs. Each technological demand element (action) is applied against each of the above-listed environmental demand elements relative to short- and long-term effects. A minus (-) represents a negative effect; a plus (+), a positive effect. It should be noted that the effects assessments are associated with site-specific situations. If these same assessments were considered on an areawide basis, the matrix would be virtually blank.

a) Surface Water Quantity (Column 31)

(i) Lines 1 and 2

The short- and long-term impacts of prospect and water-well drilling on the surface-water quantity will be insignificant.

(ii) Line 3

Drainage and/or dewatering of the mine cut will temporarily reduce the water level of the water-table aquifer, primarily within the property boundary during most of the mining operation but outside the property area when mining occurs near the perimeter of the mining property. This will temporarily reduce base flow to surface-water bodies in close proximity to the

property. Dewatering during mining should have no permanent adverse effect on existing surface-water bodies in the area. Any upper leakage of water from the Floridan aquifer to surface-water bodies in the study area is assumed to be negligible or nonexistent.

(iii) Line 4

Clearing vegetation from the land in preparation for mining will temporarily increase runoff to adjacent surface-water bodies in the area. Also, clearing will reduce losses by evapotranspiration and thus increase the availability of water for base flow. However, there will be no permanent long-term impacts.

(iv) Line 5

Burning will have the same effects as clearing.

(v) Line 6

The ore matrix is removed by draglining; however, before this occurs, the water-table aquifer must be dewatered. Thus, the effects of draglining are similar to those mentioned for draining and dewatering.

(vi) Line 7

Dredging occurs in mine cuts filled with water; as a result, a source of water is provided to the surface-water bodies located within the immediate proximity of the cut. This will have no long-term effects.

(vii) Line 8

Placing overburden in the previously-mined cut will adversely affect the hydrologic regimen of the surficial deposits since the overturned overburden is expected to reduce the hydraulic conductivity, thereby, altering the base flow to the surface-water bodies within the proximity of the property.

(viii) Line 9

The Floridan aquifer is the source of water for mining and chemical plant operations. The withdrawal of water will create a cone of depression that is limited by SWFMD regulations to a maximum drawdown of 5 feet or less at the property boundary closest to the pumping wells. The cone will decline away from the property. As a direct result of pumping, the head is reduced between the water-table aquifer and the potentiometric surface of the Floridan aquifer, resulting in flow toward the center of pumping. Thus, water levels of surface-water bodies in the immediate vicinity of the activity should be temporarily reduced. The distance and intensity of effects are a function of well characteristics. Positive effects include a reduction of evapotranspiration as a direct result of reduced water levels in the water-table aquifer.

(ix) Line 10

Water injection is a form of artificial recharge to the Floridan aquifer; the recharged water is taken from the water-table aquifer and can be defined as dewatering of an area in the vicinity of the mine cut but for a beneficial purpose. This action reduces the water levels in the water-table aquifer in the immediate vicinity of the property. Effects are similar to those discussed for draining and dewatering.

(x) Line 14

Assuming that tailings placements occurs within the mine cuts, higher transmissivity values will be created in these new deposits. The higher values will have a beneficial effect on the ability of water to flow more freely, thus creating a potential for increasing infiltration and water availability for surface-water bodies located within the mining property.

(xi) Line 15

The only adverse short- or long-term effects from slime-pond placement would occur only if the slime contents were accidently discharged to a

stream. This effect cannot be quantified, but the action would temporarily increase the flow of that stream.

(xii) Line 24

To take full advantage of rainfall, dams and levees are constructed on the mining property to aid in intercepting and storing runoff. If the dams are constructed on streams, downstreams users who may depend on these streams will be aided by the more constant discharge and will likely obtain more water for use during low flow periods.

(xiii) Line 29

The headwaters of some streams will be redirected to flow around mined areas, however, the rerouting will have no effect on dry-season flow, and wet-season flow will still be available to downstream users. Also, lakes can be created in the headwaters of several streams. Some streams in the study area are now intermittent and not flowing during dry periods. Downstream users who may depend on these streams will be aided by the creation of lakes inasmuch as a more constant discharge will likely provide more water for use during low flow periods. Discharges from the various lakes and settling areas, plus the addition of treated efluent, should provide a more regular flow for site streams during dry periods.

b) Water-Table Quantity (Column 33) and Floridan Aquifer (Column 35)

(i) Line 1

Prospect drilling in the ore zone will have insignificant short- and long-term impacts on the quantity of groundwater resources. There will be no impact at all on the Floridan aquifer.

(ii) Line 2

In general, the yields of water-table wells are so small that the phosphate industry does not use them as a supply. Even if deeper water

wells are drilled, the short- and long-term impacts of the drilling operations will be insignificant. However, the wells themselves might in the future act as conduits for the upward migration of deeper ground water of lesser quality into shallower aquifer zones of good-quality water.

(iii) Line 3

Drainage and dewatering will remove water and thus decrease the water table. This will negatively affect the availability of water from the water from the water-table aquifer. Draining and dewatering could also create a short-term impact on the Floridan aquifer during mining. The decline of water levels in the water-table aquifer could induce upward leakage of water from the Floridan aquifer in certain areas.

(iv) Line 4

Clearing vegetation from the land surface will make more water available for recharge to the water-table aquifer, thereby increasing the quantity of water in that aquifer. Clearing will not affect the quantity of water in the Floridan aquifer.

(v) Line 5

Burning will reduce losses by evapotranspiration and thereby increase the availability of water to the water-table aquifer. Burning will have no effect on the quantity of water in the Floridan aquifer.

(vi) Line 6

Draglining is synonomous with excavation by cut, in which the ore matrix is completely removed. To mine the matrix by means of dragline, the water-table aquifer would have to be dewatered. Therefore, the effects of draglining are similar to those mentioned for draining and dewatering. Draglining also could cause some loss of water from the Floridan aquifer since it removes the ore matrix. In areas where the matrix has functioned as the confining bed overlying the Floridan aquifer, draglining might provide a

conduit for water to leak upward from the Floridan aquifer into the mining cut. On the other hand, if water moves downward from the cut into the Floridan aquifer, the quantity of water in the Floridan aquifer will be augmented.

(vii) Line 7

If the dredging operations remove the confining beds overlying the Floridan aquifer, water could enter the aquifer from the cut, thereby increasing the quantity of water recharging the Floridan aquifer. Likewise, the cuts filled with water will be a supply source for the water-table aquifer.

(viii) Line 8

Placing overburden in the previously-mined cut will most likely adversely affect the hydrologic regime of the water-table aquifer, because the hydraulic conductivity of the mixed-up and overturned overburden materials can be expected to be somewhat less than the hydraulic conductivity of the undisturbed water-table aquifer. This action will have no effects on the Floridan aquifer, however.

(ix) Line 9

Because water extraction is most likely to be from the Floridan aquifer, there will be a short-term adverse effect on the water quantity of the aquifer because of the decline in the potentiometric surface resulting from pumpage.

(x) Line 10

Injection of water drained from the water-table aquifer into the Floridan aquifer will reduce the surface water quantity over the short term. The water recharged from the water-table aquifer into the Floridan aquifer will augment the availability of water in the aquifer.

(xi) Line 14

If tailings are placed in the mine cuts, their greater degree of sorting will most likely create a higher transmissivity in the newly formed surficial deposits than existed in the previous water-table aquifer materials. This higher transmissivity will have a beneficial effect on the availability of water from the water-table aquifer. Tailings placements most likely will not impact the water quantity of the Floridan aquifer.

(xii) Line 15

Slimes are normally impounded in ponds. If current practices continue, slime ponds could be sources of recharge to the water-table aquifer for many years because they drain quite slowly. In extreme cases, which have happened in the past, sinkholes could form under a slime pond, thereby permitting the slimes to drain into the Floridan aquifer. Such loss of slimes to the Floridan aquifer locally would be considered negligible.

(xiii) Line 16

Water used in recycling will indirectly affect pumpage from the Floridan aquifer in the following manner. The more the phosphate industry adheres to recycling practices, the less makeup water will be necessary; since makeup water is generally pumped from the Floridan aquifer, a very effective recycling and water-use conservation program will help to reduce pumpage from the Floridan aquifer, which, in turn, will have a beneficial effect on the quantity of water in that aquifer during both the short- and long-terms.

(xiv) Lines 17-20

The reader is referred to the discussion of Line 9.

(xv) Line 29

Drainage systems will remove water from the land surface and thereby reduce the contact time for infiltration into the underlying water-table

aquifer. Because this water is not available for recharge, the drainage system will have short-term and long-term adverse effects on the quantity of water in the water-table aquifer.

(xvi) Lines 31, 32, and 33

The way in which the mining pits are reclaimed will be very important to the quantity of water in the water-table aquifer. As an example, if the mining pits were filled with tailings, the hydraulic conductivity of the newly formed water-table aquifer in most cases would be greater than that of the original material; therefore, the effect on the availability of water from the water-table aquifer would be very beneficial. On the other hand, if the mining pits were reclaimed with overburden, a slightly lower hydraulic conductivity and an adverse effect on the availability of water in the water-table aquifer could be expected. Reclamation of mining pits is not expected to affect adversely the water quantity of the Floridan aquifer.

(xvii) Line 32

The reclamation of slime ponds will have little effect on the quantity of water in the water-table aquifer; once the slime pond is revegetated it will have very little surplus water to spare for the surrounding hydrologic systems.

(xviii) Water Use during Reclamation

A topic not covered on the matrix is water use during reclamation. Since most of the mined-out area will be reclaimed to land-surface systems that will initially need water support, a large amount of groundwater withdrawals can be expected in order to establish the first vegetation on the reclaimed land. If this were to be the case, water use for reclamation could have a short-term, slightly adverse effect on the quantity of water in the Floridan aquifer.

c) Aquifer Recharge (Column 36)

(i) Line 3

Drainage and dewatering, as stated previously, will result in the removal of water from the water-table aquifer, creating lower water levels and permitting potential for infiltration and leakage to the Floridan aquifer over the life of the mine. However, the quantities of recharge as a result of this action will be insignificant.

(ii) Line 6

In areas where the ore matrix has functioned as the confining bed overlying the Floridan aquifer, draglining might provide a conduit for water to move downward from the cut into the Floridan aquifer.

(iii) Line 9

Water extraction from the Floridan aquifer through phosphate pumpage will result in a decline of the potentiometric surface, thereby creating a potential for short-term aquifer recharge. The drawdowns estimated with the USGS digital water model for Scenario 2.15 show a recovery in the potentiometric surface by the year 2000. This would decrease the recharge potential over the entire recovery area.

(iv) Line 10

The water injected from the water-table aquifer into the Floridan aquifer will augment the availability of water.

(v) Lines 17-20

The reader is referred to the discussion of Line 9.

d) Erosion (Column 37)

(i) Line 2

When an area is cleared in preparation for water-well drilling, the removal of vegetation results in erosion. Although this continues throughout the life of the operation, the overall effect is insignificant.

(ii) Line 4

Clearing the land surface of vegetation in preparing for mining will result in a temporary increase in runoff and erosion (siltation) to surface-water bodies adjacent to the area, but there will be no permanent, long-term impacts.

(iii) Line 5

The reader is referred to the explanation of Line 4.

(iv) Line 8

If overburden from the initial mine cut is placed on the adjacent surface, runoff from rainfall will erode it into the adjacent cut and/or adjacent surface-water bodies, thus increasing siltation.

(v) Line 12

The reader is referred to the discussion of Line 8.

(vi) Line 24

The construction of dams and levees or surface excavation will increase surface erosion (siltation) into the streams in the immediate area. This will occur until the area is revegetated.

(vii) Line 29

The act of rerouting streams will increase erosion and siltation into adjacent streams in the area. Once vegetation becomes reestablished, however, the silt present in the streams will eventually settle.

(viii) Lines 31, 32, 34, and 35

The act of reclaiming mine pits, slime ponds, plant sites, and dams and levees will scar the land surface and leave it open to the elements. This will result in increased runoff and thus erosion and finally siltation into the local streams.

e) Flooding (Column 37)

(i) Line 15

Slime placement could have a positive short- and long-term effect on flooding since these ponds act as catchment for rainfall.

(ii) Line 22

The reader is referred to the explanation of Line 15.

(iii) Line 24

Dams and levees serve to contain runoff and rainfall, so constructing them will reduce the probability of flooding.

(iv) Line 29

The rerouting of streams within a mining area will likely increase the probability of flooding since the topography will be young, floodplains will not have formed, and vegetation will not have established itself.

(v) Line 31 and 32

The reclamation of mine pits and slime ponds, by creating lakes and reducing topographic relief, would likely reduce the possibility of flooding.

(vi) Line 35

The reclamation of dams and levees would remove the containment of runoff and rainfall, thus increasing the possibility of flooding.

f) Cavitation (Column 39)

(i) Line 9

Water extraction from the Floridan aquifer would not directly cause cavitation but indirectly could have a dramatic impact. Continued pumpage reduces head pressures; if cavities are located within the area, the reduction in pressure can collapse the overlying material into the cavity.

(ii) Line 12

The additional weight of product storage on the land surface could result in collapse into an underlying cavity.

(iii) Lines 14 and 15

The reader is referred to the discussion of Line 12.

(iv) Line 22

Waste placement involves the use of large gypsum ponds. It is important to know how much waste in these ponds seeps into the underlying sediments, how far it travels, its concentrations at certain points. Where acid materials from the gypsum ponds leak downward and dissolves the underlying limestone, sinkholes may develop beneath the ponds.

2) Water Quality

The following paragraphs discuss Scenario 2.15 as it relates to probable effects on the quality of water in the study area's surface- and groundwater systems. Volume V, Chapter 1, Section 2 (TI 1977e) dealt with present water quality conditions and, where information was available, projected water quality. The present discussion focuses only on the effects of phosphate industry activities, since sufficient data were not available regarding projected point sources and runoff in all segments of the study area.

Areas affected by the phosphate industry under this scenario for the short term (1977-85) are in southwestern Polk County and southeastern Hillsborough County. The river segments which will be affected (TI 1977e: Volume V, Chapter 1, Section 2) will be the upper portion of the Peace River (designated P.1 and P.4 in Volume V), McCullough Creek and Whidden Creek (P.5), the upper areas of Payne and Little Payne Creeks (P.8), the north and south prongs and main stem of the Alafia River (A.1, A.2, A.4, A.5, A.8, A.9, and A.12), and the northern portion of the Hillsborough River (H.1). All of these are Class-III waters, and all except segment A.1 currently exceed water quality regulations.

Activities for the long term (1985-2000) affect essentially the same areas as in the short-term outlook, with the addition of the upper portion of the Little Manatee River (LM.1) and farther south along the Peace River (P.7). The latter is Class III water and currently exceeds standards for many parameters. Segment LM.1 is also Class-III water and is known to exceed standards in regard to dissolved oxygen, alkalinity, and conductivity (see TI 1977e:Volume V, Chapter 1, Section 2, Table 2.12).

For each of the technological demand elements that are discussed next, an effect will be determined regarding the water quality in each of the following three areas: surface water (matrix column 30), water table (matrix column 32), and the Floridan aquifer (matrix column 34). Each technological demand element will be addressed as the row (line) number on the matrix.

a) Prospect Drilling (Line 1)

Prospect drilling's impact on the surface water or water-table quality is insignificant. There is no effect on the Floridan aquifer.

b) Water-Well Drilling (Line 2)

Water-well drilling itself has no significant effect on water quality over either the short or long term, but the water wells could act as a conduit if not properly cased to the zone of extraction, allowing water of poorer quality in deeper zones to migrate into shallow-water areas of better quality. Therefore, a potential negative (indicating deterioration) is assigned for the water-table aquifer box.

c) Draining/Dewatering (Line 3)

This activity will lower the water-table aquifer in the immediate area (Beker Phosphate nd, CF Mining 1973) and may, where mining occurs near the boundary of the property, temporarily lower the water-table aquifer off of the property. This dewatering process may expose the water-table aquifer minerals to an oxidizing environment, which could greatly affect the chemical quality of the water. Subsequent to the oxidation products possibly being leached downward by percolating rainwater, recovery of the water level could cause a highly mineralized solution to enter the groundwater system. Oxidation of sulfide materials is the principal cause of groundwater contamination near mining areas (Miller et al nd).

If the dewatering process results in the discharge of drained water to surface-water features, surface-water quality may be temporarily and locally degraded as a result of the normally low pH and high color water from swamp areas being discharged to streams; however, this contamination is, on the regional scale, insignificant.

The dewatering process also may decrease the base flow of bordering streams, potentially increasing mineralization; however, this also is considered insignificant on a regional scale.

d) Clearing (Line 4)

The most significant water quality effect caused by clearing is the increased erosion and subsequent siltation in streams of the immediate vicinity. Clearing on swamp and stream areas eliminates the aquatic flora, which is so important in nutrient uptake and water purification. This will cause some deterioration of surface-water quality and reduce the natural streamflow stabilization, which could cause increased variability in water quality. The clearing process will decrease the filtering potential of water percolating into the water table; at the same time, the removal of forested areas where much humic material collects will decrease the tannin and color of waters running into surface streams and of waters percolating into the water-table aquifer. There will be no effect on the Floridan aquifer water quality.

e) Burning (Line 5)

The effects from burning are essentially the same as those from clearing.

f) Draglining (Line 6)

Since draglining occurs after dewatering, the effect of dewatering is covered in technological demand element 3. In areas where the phosphate matrix that is being extracted has functioned as a confining bed overlying the Floridan aquifer, the removal of the matrix by draglining could allow water to leak upward from the Floridan aquifer, thus causing the aquifer to lose the water. However, this loss would be insignificant and would not offer any potential for saltwater encroachment. If water from runoff were to move into the Floridan aquifer, there could be a slight local deterioration of water in the Floridan; however, such an event is considered to be insignificant regionally.

g) Dredging (Line 7)

Dredging will adversely affect the water quality of the surrounding water-table aquifer inasmuch as water within the cut, which will contain

a relatively large amount of dissolved solids, will enter the water-table aquifer. If dredging removes the phosphate matrix at a depth at which it composes part of the continuing layer to the Floridan aquifer, water could enter the aquifer from the cut, degrading the water quality. There is no effect on surface-water quality.

h) Overburden Placement (Line 8)

Placing overburden in the previously mined cut will not affect water quality over the short term. Over the long term, however, the overburden material, which becomes a part of the new water table as mining progresses and more overburden is accumulated, will have a degrading effect on the new water-table water quality; the overburden material will impart more dissolved solids to the water-table aquifer than existed in the old water table as water percolating through the new, loose soils picks up the dissolved material. Regionally, this activity will have a slight negative but quite localized effect on the water-table aquifer. The surface water in the area will not be affected since any runoff from the overburden material will be contained within the mining area.

i) Water Extraction (Line 9)

Extracting water from the Floridan aquifer will have minor impacts on the aquifer's quantity locally, potentially causing some drawdown of the water-table aquifer locally. This, in turn, may cause greater-than-normal variation in the water-table aquifer level, which will tend to increase the total dissolved solids in the water table due to oxidation that may occur. The decrease in the water-table aquifer may cause some decrease in base flow to surrounding streams, which may increase the concentration of some chemical constituents; however, the effects of this activity on a regional scale are considered to be insignificant. The decline in the potentiometric surface of the Floridan aquifer during pumpage will not be sufficient to cause concern about saltwater contamination from deeper zones.

j) Water Injection (Line 10)

Water injection of water from the water-table aquifer to the Floridan aquifer for dewatering may cause some very local contamination of the Floridan aquifer, but this contamination will be insignificant on a regional scale. The effects on the water-table aquifer were covered under the dewatering technological demand element (Line 3).

k) Equipment Relocation (Line 11)

Moving large draglines across streams or on roads constructed for "walking" them may cause some local contamination due to sediment and resulting turbidity. The effects will be highly localized, however, and insignificant on a regional scale.

l) Product Storage (Line 12)

Graded piles of rock stored within the confines of a beneficiation plant may, if not covered for protection from rain, will cause some contamination, mostly phosphates and fluorides, to be carried into the surface water bodies and, through percolation, into the water-table aquifer. The effect is temporary and localized but may be identifiable. If all regulations are met, surface runoff will be contained within the property so that contamination to surface water outside the property boundary will not occur.

m) Product Drying (Line 13)

This activity has no effect on water quality.

n) Tailings Placement (Line 14)

Sand tailing placed into the older mining cuts will eventually become the new material comprising the water-table aquifer. This material, of higher transmissivity than the material it replaces, will allow greater recharge to the water-table aquifer and will reduce surface runoff. Dissolved solids associated with the new water-table aquifer of the area may

temporarily increase, but this is expected to be insignificant on a regional scale.

o) Slime Placement (Line 15)

The biggest concern posed by slime placement is the potential for the retaining structure to fail or the safety canal surrounding the slime ponds to overflow. There have been incidents of surface-water pollution as a result of slime-pond dike failures (TI 1977e:Volume V, Chapter 1, Section 2). While new regulations that are being instigated will lower the potential for slime-pond surface-water pollution in the future, the potential still exists and therefore has a negative effect.

There is generally assumed to be little seepage of water from slime ponds into the water-table aquifer due to sealing by fine particles in the slime pond; however, the potential for phosphate and fluoride contamination of the water-table aquifer exists although data are not available to substantiate the possibility. If sinkholes, which are fairly common in the phosphate mining area of Florida, develop beneath slime ponds, the potential for contamination of the water-table aquifer and Floridan aquifer exists.

p) Water Use/Recycle (Line 16)

The recycling of water within mining and processing activities to meet the BPT and BAT guidelines pursuant to FWPCA 1972 (amended) will cause a decrease in the pollutants being discharged to the surface water bodies; however, the effects that the impounding may have on stream flows and the associated water quality deserves further investigation.

q) Manufacture of Sulfuric Acid, Fertilizer Products, Animal-Grde Phosphate, and Elemental Phosphorus (Lines 17-20)

The effects of these processing activities on water quality is related to the discharge it wastes, which is covered under (p) above.

r) Waste Treatment (Line 21)

The use of impoundments for treating wastewaters associated with processing poses a large potential threat to the groundwater systems, but in the impoundments where the wastewaters settle, a fine sediment layer is formed along the bottom, tending to restrict any downward percolation of the wastewaters. Monitoring water quality surrounding such wastewater impoundments in Polk County showed that the water was of good quality and not contaminated (Beker Phosphate nd). If wastewaters in the settling lagoons are acidic, sinkholes can be created beneath the impoundment and such an occurrence would cause collapse and allow bad-quality water to contaminate both the water table and the Floridan aquifer. A threat if a break in a dam surrounding the wastewater treatment impoundments poses potential contamination of surface-water bodies receiving the discharge. THe more stringent criteria for treatment and retention of wastes (BPT and BAT) will lessen the adverse impact of wastewater discharges.

s) Waste Placement (Line 22)

Probably the largest potential problem associated with the chemical processing of phosphorus with respect to water quality is the placement of gypsum ("gyp stack"). Approximately 1.5 tons of gypsum are produced per ton of phosphate rock processed. The sizes of gypsum disposal ponds range from several hundred to over a thousand acres. The gypsum stack (cake) is often more than 100 feet (30.5 meters) high and eventually covers a large percentage of the gyp-pond surface. When there is no longer an adequate water-cooling surface, the pond must be enlarged. Three gyp ponds have been abandoned over the past 20 years; the pond waters are still highly contaminated, and the areas covered by the ponds are useless. One of these ponds is no longer owned by the company, and over 1,000,000 gallons per year of acidic water (pH less than 3.0) still seeps through the dike and drains to surface waters 20 years after abandonment.

All chemical plants now practice 100 percent recirculation of contaminated water, including gypsum slurry and scrubber water, through the gyp

pond except during periods of extremely heavy rainfall. During such periods when discharge is necessary, a 2-stage liming and settling process is used, increasing the pH to 6.0-7.0 and decreasing fluoride to approximately 10 milligrams per liter, phosphate as phosphorus to approximately 10 milligrams per liter, and radionuclides to less than 5 picocuries per liter (considered to be acceptable levels). Some of the chemical plants also totally recycle high-volume noncontaminated water, most of which is cooling water; plants that discharge must continually monitor and sometimes treat the cooling-water discharge, since it can become contaminated by spills, leaks, or other in-plant accidents.

Harmful pollutants in discharges to surface waters include phosphate, fluoride, ammonia, acidity, and radionuclides. Even after conventional treatment, phosphates and ammonia are still in harmful quantities, primarily because they are plant nutrient materials that overenrich downstream estuaries. At low river flows, ammonia also has a potential of reaching concentrations toxic to fish and other organisms in the receiving water.

Another potential pollution problem is seepage from the highly contaminated gyp ponds to ground and surface waters. Most surface seepage is controlled with perimeter ditches, whereby seepage through dikes is pumped back into the ponds, but the extent and total effects of seepage into groundwater is not known. Contaminants are probably absorbed and neutralized as the seepage passes through clay and limestone formations, but a potential of sinks and fissures in the limestone formations of the Floridan aquifer are still a concern.

Toler (1967) found the following water quality associated with a "gyp pond" in Polk County:

	parts per million (except specific conductance, pH, and color)
Silica (SiO_2)	1,180
Iron (Fe)	87
Aluminum (Al)	64
Manganese (Mn)	2.7
Calcium (Ca)	1,110
Magnesium (Mg)	50
Sodium (Na)	155
Potassium (K)	12
Total Acidity as H+	123
Bicarbonate (HCO_3)	0
Sulfate (SO_4)	2,710
Chloride (Cl)	37
Fluoride (F)	1,410
Nitrate (NO_3)	0.5
Phosphate (PO_4)	7,540
Dissolved Solids	14,400
Total Hardness as $CaCO_3$	2,980
Non-Carbonate hardness as $CaCO_3$	2,980
Specific electrical conductance in micromhos	10,100
pH	2.0
Color	140

While there is insufficient evidence to show substantial detrimental quality effects from bottom seepage on ground water and dam seepage on surface water, the potential warrants monitoring the ground water surrounding these waste stacks.

t) Water Use/Recycle (Line 23)

To meet BPT and BAT guidelines, many phosphate operations are beginning to use groundwater injection of wastewaters as an alternate method of disposal. This has the potential of degrading the water quality of the Floridan aquifer, but data are insufficient to permit assigning an effect.

u) Lines 24-29

The construction of all of the items listed in the matrix will have local effects - increased sedimentation and turbidity to the streams draining the area - but should not significantly affect groundwater systems.

v) Reclamation of Mining Pits (Line 31)

Reclamation either by tailings or overburden will impart additional dissolved solids to the new water-table aquifer as rainwater

percolates into it. No adverse effects on surface-water quality (other than slight temporary increases in suspended solids during machine operation) or in the Floridan aquifer are anticipated.

w) Reclamation of Slime Ponds (Line 32)

The reclamation of slime ponds will have various effects on the area's water quality, depending on the method of reclamation. Available data are not sufficient for effects assignment.

x) Reclamation of Plant Sites (Line 34)

Reclamation of plant sites creates many new water impoundments where land or streams existed previously. Since the reservoirs accumulate nutrient material, which may lead to overenrichment and the subsequent problems associated with eutrophication, the effect is to lower water quality.

y) Lines 37-43

The transportation of all items in the matrix should have negligible effect on the water quality of the area.

3) Biological

Analyzing the impact of present and projected activities of the central Florida phosphate industry on the aquatic biota of the 7-county study area has been a complex task not only because of the general paucity of data relative to some regional biotic components but also because of some unknown water quality and hydrologic considerations relative to disturbing wetlands (see the subsection on water quantity in Section 6). To aid perspective and understanding while reviewing results of the impact assessment, the following paragraphs provide information on the:

- Scope of assessment
- Ecological background

- Terminology
- Sources of effects of the phosphate industry on aquatic biota
- General assessment of the various development scenarios as they relate to regional aquatic biota
- The numeric system utilized in the impact assessment matrices

a) Scope of Assessment

The first step in analyzing impacts of the phosphate industry on regional aquatic biota was to define boundaries for consideration of effects. Considered pertinent to the impact analysis on a spatial basis were all surface water bodies within the 7-county study area as well as nearshore marine waters (principally Tampa Bay and Charlotte Harbor and the estuaries of contributing rivers flowing from the study area) that could possibly be affected by the phosphate industry. Temporal boundaries included both short-term (present to 1985) and long-term (1985-2000) effects intervals. Boundaries for incorporation of industry actions for consideration were established with the development of the five alternative scenarios described previously in this text. Another categorization was primary versus secondary effects (although the distinction between the two was often difficult).

Although wetlands might be considered in some instances to be a type of aquatic habitat, they are treated as a separate entity in other sections of the effects assessment document and are not discussed in this section except as they relate to identifiable surface water bodies. Additionally, only vertebrates (other than fishes) that truly inhabit the aquatic environment (e.g., manatee, alligator, and certain turtles) are considered within this assessment of effects on aquatic biota; however, a wide variety of other vertebrates rely upon aquatic habitats for food and cover, so it should be remembered that alteration of the aquatic habitat will also affect these animals. The effects of industry activities on these water-associated vertebrates are discussed in sections of this document relating to the uplands and wetlands environments.

b) Ecological Background

To make projections of the impact of the phosphate industry, it was necessary to establish a baseline documentation of existing conditions of the aquatic environments and biota of the study area. These data are included in the aquatic biota volume (TI 1977e: Chapter 2, Section 2). As indicated, the existing data for some areas (particularly standing waters [lakes and ponds]) were sparse.

Results of the baseline survey of existing ecological conditions showed that the biota of the fresh, brackish, and marine waters of the study area comprises unusually rich and diverse assemblages of aquatic organisms. The high diversity can be attributed largely to the study area's geographic position: it lies at the intergrade of temperate and subtropical climates. Winter water temperatures seldom drop low enough to kill tropical organisms, and summer water temperatures are moderate enough to be tolerated by most of the temperate species. The high productivity and abundances of organisms in the study area can be related to the unusually high fertility of the surface waters. However, although the local climate is mild enough to support essentially a year-round growing season, seasonal influences in biotic cycles are evident (although more muted than in temperate climates). A major influence is the "wet" and "dry" season periodicity, which regularly alters streamflow regime, freshwater discharge into the estuaries, and the amount of standing water in the study area.

c) Sources of Effects

Reduced to simplest form, there are three ways in which the phosphate industry can affect the aquatic biota of the study area:

- Direct disruption by physically altering an existing aquatic habitat
- Alteration of surface water quantity
- Alteration of water quality of existing habitats

Existing aquatic communities can be physically disrupted through either construction activities or mining excavation in aquatic habitats such as streams, ponds, and wetlands. Although local effects may be great, the frequency and magnitude of this type of impact from a regional perspective are relatively low.

Water quantity can be altered by the discharge of waste water obtained from ground water to local surface water bodies or by the dam and levee construction and mining excavation that would alter natural drainage patterns. The utilization of surface water for mining or processing also would represent a significant alteration of water quantity, but this practice is of limited scale in the study area.

The phosphate industry can alter water quality by:

- Increasing turbidity and siltation of local drainage courses through land preparation, mining, excavation, and construction
- Spilling phosphate slime into local water bodies
- Discharging process water and other liquid wastes to local water bodies
- Spilling mineral acids and other materials during manufacturing or processing
- Allowing waste and product storage piles to seep

d) Environmental Demand Elements

Six basic environmental elements (Table 2.8) were selected as decision "indicators" for the assessment of effects. The selection allowed assessment of effects on "important species" of the region (threatened and endangered, commercial and/or recreational, nuisances and pests) as well as on the general species assemblages in various aquatic communities (standing water, running water, bays, and estuaries). Three basic decision indicators, or subelements, were applied to each aquatic community in order to address the potential effects on water quantity (resource potential for standing water, flow regime for flowing water, and freshwater discharge

patterns for bays and estuaries), water quality (habitat quality), and community structure. Feeding into each of these 13 environmental elements for aquatic biota selected for the effects assessment matrix is a supporting heirarchy of environmental considerations (an example of which is presented in Figure 2.2).

Table 2.8. Aquatic Biota Environmental Demand Elements for Environmental Effects Matrix

		Threatened and Endangered Species	1
		Commercial and Recreational Species	3*
		Nuisance and Pest Species	4
AQUATIC BIOTA	Standing Water	Resource Potential	5
		Habitat Quality	6
		Community Structure	7
	Running Water	Flow Regime	8
		Habitat Quality	9
		Community Structure	10
	Bays and Estuaries	Freshwater Discharge Patterns	11
		Habitat Quality	12
		Community Structure	13

*Environmental Demand Element No. 2 – Ecologically Significant Species – not employed for aquatic biota effects assessment.

The following paragraphs discuss some of the more important support considerations.

(i) Threatened and Endangered Species

This category includes all aquatic species in the study area that have been designated endangered, threatened, rare, or of special concern by either federal or state agencies or other institutions. These species are listed in Table 2.9, as is their relative importance ranking.

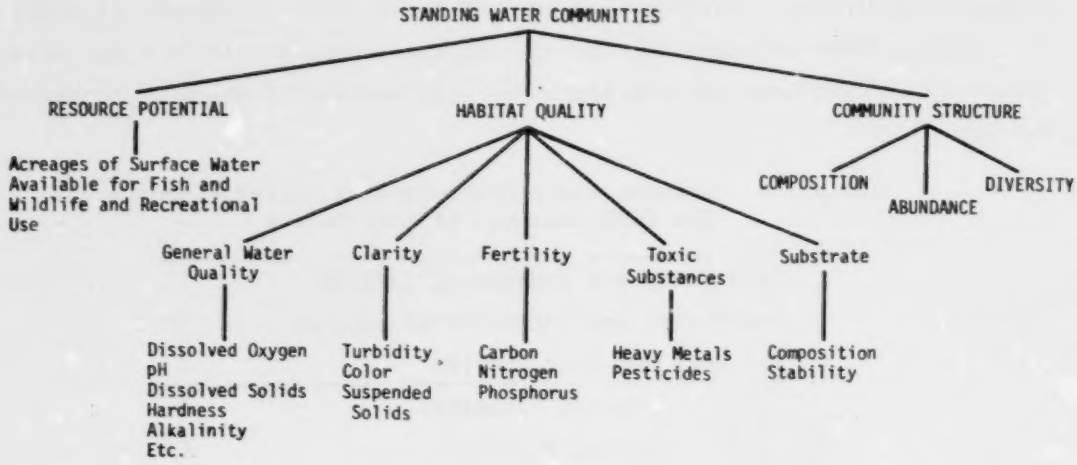


Figure 2.2. Consideration Hierarchy for Assessing Effects on Standing-Water Communities

Table 2.9. Study Area Aquatic Species Designated Endangered, Threatened, Rare, or of Special Concern

Species	Importance Ranking	Status
Atlantic Geoduck	13	Rare (FCREPA)
Opossum Pipefish	12	Rare (FCREPA)
Mangrove Crab	9	Threatened (FCREPA)
Atlantic Sturgeon	11	Threatened (FCREPA)
Rivulus	10	Threatened (FCREPA)
Suwanee Cooter*	7	Threatened (FGFWFC, FCREPA)
Atlantic Loggerhead	8	Threatened (FGFWFC, FCREPA)
American Alligator*	6	Threatened (USDI, FGFWFC); special concern (FCREPA)
Atlantic Leatherback Turtle	5	Endangered (USDI; rare (FCREPA)
Atlantic Ridley	1	Endangered (USDI, FGFWFC, FCREPA)
Atlantic Green Turtle	2	Endangered (USDI, FGFWFC, FCREPA)
Atlantic Hawksbill	3	Endangered (USDI, FGFWFC, FCREPA)
Manatee*	4	Endangered (USDI); threatened (FGFWFC, FCREPA)

*Potentially affected by phosphate industry activities.

Only the Suwanee Cooter, American alligator, and manatee are expected to be potentially affected by phosphate industry activities.

Information regarding the life history and distribution of each of these species appears in the aquatic biota volume (TI 1977e: Chapter 2, Section 2).

(ii) Species of Commercial and/or Recreational Value

This is one of the most important environmental elements for the study area, since commercial and recreational species represent an extremely valuable resource to the central Florida region. Categories of commercially and recreationally important species considered in effects assessment are indicated in Table 2.10, along with some examples under each category.

Table 2.10. Species of Commercial and/or Recreational Importance

Categories	Importance Ranking	Examples
Freshwater		
Game fishes	4	Largemouth bass, bream (bluegill, redear sunfish, etc.)
Commercial fishes	6	Channel catfish, blue tilapia
Bait/forage fishes	7	Minnow, shiner
Estuarine		
Game fishes	1	Snook, tarpon, spotted seatrout, red drum, etc.
Commercial fishes	3	Mullet, crevalle, pompano, red snapper, spotted seatrout, grouper, etc.
Bait/forage fishes	5	Bay anchovy, menhaden, silverside, etc.
Commercial invertebrates	2	Shrimp, blue crab, stone crab, etc.

Species of commercial and recreational importance to the study area and their relative values are detailed in the aquatic biota volume (TI 1977e: Chapter 2, Section 2).

(iii) Nuisance and Pest Species

The same environmental features that provide the outstanding biotic resources of the fresh and salt waters of Florida also promote the possibilities that certain native and exotic species populations (TI 1977e: Volume V, Chapter 2, Section 2) will grow to nuisance levels. For purposes of impact assessment, the nuisance and pest organisms have been categorized for consideration as shown in Table 2.11.

Table 2.11. Aquatic Nuisance and Pest Species in Study Area

Categories	Importance Ranking	Examples
Freshwater		
Macrophytes	2	Water hyacinth, Hydrilla, water milfoil
Algae	6	Filamentous and colonial green and bluegreen algae
Midges/Mosquitos	5	Midges/mosquitos
Asiatic clam	8	Asiatic clam (*Corbicula*)
Native nuisance fishes	9	Gizzard shad, bowfin, gar
Exotic fishes	3	Tilapia, walking catfish
Estuarine		
Gymnodinium (red tide)	1	*Gymnodinium*
Gracilaria (red alga)	4	*Gracilaria*
Fouling organisms	7	Barnacles, bivalves, algal mats

(iv) Resource Potential (Standing Water)

This element relates simply to the acreages of standing water available for development of aesthetic, recreational, commercial, and/or habitat value.

(v) Habitat Quality (Standing Water)

Numerical entries into the environmental effects matrix for this element were developed in a heirarchal fashion, as shown in Figure 2.2. Principal considerations for this category were general water quality, water clarity, fertility, toxic substances, and substrate.

(vi) Community Structure (Standing Water)

Three basic community descriptors were used as determinants for this category: composition (what species), abundance (how many), and diversity (variety of species and relationship of number of species to total number of organisms).

Although productivity is another important ecological descriptor for aquatic communities, it can be assessed indirectly (although subjectively) by examining the characteristics of community structure.

(vii) Flow Regime (Running Water)

Considered in this environmental category were alterations in quantities of surface-water flow and changes in discharge (runoff) patterns within affected drainage courses.

(viii) Habitat Quality (Running Water)

This category was examined in much the same fashion as that described previously for habitat quality of standing water (v).

(ix) Community Structure (Running Water)

The same considerations used for determining alterations of community structure in standing water (composition, abundance, diversity) were applied also to the running-water ecosystems.

(x) Freshwater Discharge Patterns (Bays and Estuaries)

The amount and periodicity of discharge of fresh water from major contributing streams to Charlotte Harbor and Tampa Bay are very important to the maintenance of productive and desirable estuarine communities; to a large extent, they govern the occurrences and distributions of organisms found in the two embayments. Thus, this decision indicator is one of considerable importance to the assessment of effects on the bay and estuarine communities.

(xi, xii) Habitat Quality and Community Structure

Both the habitat quality and community structure categories for bay and estuarine communities closely follows the considerations presented previously for standing- and running-water communities (refer to Figure 2.2).

(xiii) Demand Element Ranking

To arrive at an effects determination when diametric effects on two aquatic communities were encountered, it was necessary to assign an importance to each principal environmental demand element. This was accomplished by simply ranking the elements in order of their economic and social importance within the study area:

(1) Commercial and recreational species
(2) Bays and estuarine communities
(3) Nuisance and pest species
(4) Running-water communities
(5) Threatened and endangered species
(6) Standing-water communities

e) Numeric Impact Assessment System

In the aquatic biota effects assessment, the system devised for assigning a value to impact was necessarily unique. The latitude of values available for assignment was from 0 to -10 for adverse effects and 0 to +10 for beneficial effects. The data available were not extensive enough to support discrimination of effects beyond rather subjective categories, but this is not to be interpreted as a declaration of weakness in the assessment; there are few biological systems in the world that have been studied sufficiently to allow good quantitative assessment of impact through predictive modeling.

All numerical assignments for effects were developed from a regional perspective. Although there may be some severe local effect of an action, it may rate relatively low from the regional perspective.

It was readily apparent in preparing the impact statement that certain complexities in defining effects of the phosphate industry on regional aquatic biota would require clarification for the reviewer. Thus, as premises to the impact assessment, these clarifications are as follows:

- Except for certain impoundments, the three types of aquatic ecosystems in the study area (standing water, running water, and bays and estuaries) are generally interconnected; for example, any action affecting a headwater stream could potentially affect an estuary as well.

- An effect that is considered detrimental to one species or community is quite likely to be beneficial for another; for example, heavy nutrient additions to a small headwater stream might promote undesirable community alterations, whereas the contribution of additional nutrients to a downstream estuary might increase productivity and improve the fisheries. Such diametric effects must necessarily be assessed as a "net effect" within the context of potential benefit or liability to man.

- A perturbation of an aquatic ecosystem (e.g., a chemical spill in a stream) will be relatively short-lived because of mild climate and an extended growing season, relatively fertile waters, diverse

and rich aquatic communities, and the interconnection of many water bodies. There may be some community shifts, but a functioning aquatic community will reestablish in less time than would be expected in a temperate region.

- The construction of a suitable impoundment produces a net positive effect for aquatic biota because it represents a potential aquatic resource (e.g., recreational fishery, habitat for waterfowl, etc.); although to a lesser degree, it also represents some negative effects (e.g., alteration of runoff patterns to local drainage courses and the potential for incresed nuisance conditions caused by mosquitos and midges.

- Although an industry action per se might have no direct effect on aquatic biota, certain activities do have a potential for deleterious effects. Two cases in point are slime placement and sulfuric acid processing; while neither directly affects aquatic biota, both represent a potential hazard to aquatic biota through spillage. For purposes of this impact assessment, actions representing substantial potential harm to aquatic biota are considered as negative or deleterious impacts, with the numerical assignment being based on consideration of both the likelihood and magnitude of potential harm.

d. Sensitive Natural Areas

Sensitive biological and geological areas (Plate 3 in map pocket) are critical components of the environmental systems of the study area. The biological areas include natural habitats of rare and endangered flora and fauna, wetlands, and other natural areas that provide recreational opportunities, especially observations of native plants and animals. Sensitive geological natural areas include flood plains, sinkholes and subsidence zones, and aquifer recharge areas.

1) Biological Areas

The following annotated list of sensitive biological areas includes lands owned by private organizations, foundations, and industry, as well as those under state and federal jurisdiction. They represent most of the wildlife refuges, wilderness habitats, sanctuaries, and aquatic pre-

serves in the study area. Among other sensitive areas within or partially in the seven counties are parcels proposed for designation as environmentally endangered lands under Florida law as well as proposed for various outdoor classrooms and environmental laboratories. These areas are listed and described in the inventory of fish and wildlife of the study area prepared by the Archbold Biological Station (Layne et al 1977) for the U.S. Fish and Wildlife Service. Also in that report are geographic data pertinent to habitats of fully protected species, including approximate locations of nests of the Southern Bald Eagle and major concentrations of the Florida panther. Although the species are protected, their habitats are not unless they are declared critical as in the case of the manatee. Principal habitats of the Florida panther apparently are near and in Lake Kissimmee and Myakka River state parks and, like habitat in other delineated sensitive areas, are not likely to be disturbed.

- Sanctuaries

Name	Location	Description
Babson Park	Polk County in Babson Park between Frostproof and Lake Wales	2 hectares (5 acres) of scrub and oak vegetation owned by Webber College and used by Ridge Audubon Society
Buttonwood Rookery	Charlotte County on Rookery and Buttonwood Islands in Lemon Bay, both resting rookeries and feeding grounds on a regular basis for a wide variety of bird species.	19 hectares (47 acres) comprising sand and mud flats, cabbage palm, and mangrove. Nesting colony of egrets.
Combee	Polk County 3.2 kilometers (2 miles) east of Lake Parker	A 36-hectare (90-acre) unmined cypress swamp owned by American Cynamid Company and leased by Florida Audubon Society.
Mary Male Sanctuary	Polk County north of Lake Wales on perimeter of Lake Pierce	8.4 hectare (21 acres) of cypress-hardwood swamp owned by Florida Audubon Society and used by the local Ridge Audubon Society.

Name	Location	Description
Mountain Lake Sanctuary	Polk County north of Lake Wales	51 hectares (128 acres) owned and maintained by American Foundation, Inc. Approximately half of acreage cultivated in garden flora. Pine Ridge Nature Reserve comprises virtually untouched ridge habitat; includes highest point in peninsular Florida.
Myakka Audubon Society Sanctuary	Manatee County 32 kilometers (20 miles) east of Sarasota off Florida Highway 780	70 hectares (175 acres) of marsh, hardwood hammock, and pine flatwoods owned by Jasper Crowley Museum and Nature Center Corporation and used by the Myakka Audubon Society.
Orange Park	Polk County 4.8 kilometers (3 miles) northeast of Lake Parker.	A phosphate settling basin of approximately 257 hectares (635 acres) rich in bird life.
Panther Point Wildlife Sanctuary	Polk County north of Barton on south shore of Lake Hancock	Approximately 240 hectares (600 acres) of mixed hardwood (red maple, elm), and scrub oak-myrtle owned by Armour & Co.
Saddle Creek Sanctuary	Polk County south of U.S. 92 near Lakeland	120-hectare (300-acre) old mining area with lake and riparian habitat. Owned by American Cyanimid, leased by the Florida Audubon Society, used by the local Lake Region Audubon Society, and not maintained.
Sydney	Hillsborough County 4 kilometers (2.5 miles) southwest of Plant City	A 69-hectare (170-acre) phosphate mined area owned by American Cyanamid and now a cooperative wading-bird sanctuary.
Tampa Bay	Hillsborough County in Hillsborough and Tampa Bays near mouth of Alafia River south of Tampa	Approximately 81 hectares (200 acres) of breeding rookeries for herons, ibises, and egrets and breeding sites for Brown Pelicans and Roseate Spoonbills.

Name	Location	Description
Teneroc Wildlife Sanctuary	Polk County north of U.S. 92 and east of Lakeland	An approximately 160-hectare (400-acre) old mining area owned by Borden, Inc., and comprising settling basin and riparian habitat (willow, wax myrtle, scrub oak).
Tiger Creek	Polk County west of Lake Weohyakapka along spring-fed Tiger Creek	232 hectares (580 acres) owned by Nature Conservancy and comprising sandhills, pine scrub, hardwood hammock; Osprey, Sandhill Cranes, Wild Turkeys.
Walk-in-the-Water Creek	Polk County near Weohyakapka Creek in east-central Polk County	3.6 hectares (9 acres) of pine flatwoods, hardwoods, and palm hammock owned by Nature Conservancy.

- Aquatic Preserves

Name	Location	Description
Cape Haze-Gasparilla Sound National Aquatic Preserve	Charlotte-Lee counties on the southeastern shoreline of Charlotte Harbor between the harbor and Gasparilla Sound	Entirely mangroves - red, black, white (with buttonwood).
Cockroach Bay State Aquatic Preserve	Hillsborough County on eastern shore of Tampa Bay	13 kilometers (8 miles) of shoreline, or approximately 600 hectares (1,500 acres), about one-half of which is aquatic. Wetlands portion is primarily mangrove.
Egmont Key National Wildlife Refuge	Hillsborough County at mouth of Tampa Bay	Vegetation is primarily Brazilian pepper, cabbage palm, Australian pine, and sea oats; few mangroves.
Island Bay National Wildlife Refuge	Charlotte County: several islands within the Cape Haze-Gasparilla Sound Aquatic Preserve.	Primarily red and black mangrove. The small, older spoil island (0.2 hectares, or 5 acres) has 3,000 Laughing Gull nests and 10 pairs of Royal Terns.

Name	Location	Description
Passage Key National Wildlife Refuge	Manatee County: small island (approximately 3.2 hectares, or 8 acres) in southeastern part of Tampa Bay	Formerly mangrove; presently sea oats (Uniola paniculata) and saltgrass, with invading Australian pines eliminated. Inundated during very high tides.

- Wildlife Management Areas

Name	Location	Description
Avon Park State Wildlife Management Area	Polk County 8 kilometers (5 miles) southeast of Frostproof.	Approximately 1,792 hectares (4,480 acres) of primarily pine flatwoods, saw palmetto and wiregrass; 1.6-kilometer (1-mile) wide strip of Lake Wales Ridge extends through the entire area. Hardwood hammocks are adjacent to Lake Arbuckel and the Arbuckel stream - a lengthy cypress slough, scattered bay heads, cypress ponds, and prairie ponds.
C.M. Webb State Wildlife Management Area	Charlotte County 6.4 kilometers (4 miles) east of U.S. 17 and Florida Highway 74 on 74	25,000 hectares (62,500 acres) of predominantly pine flatwoods, including tree farms. Fish management of water bodies.
Green Swamp State Wildlife Management Area	Polk County: northwestern corner 32 kilometers (20 miles) north of Lakeland	Approximately 640 hectares (1,600 acres) in study area that include cypress swamp and pine flatwoods and an extensive groundwater recharge area. The physical unit "Green Swamp" is larger than the wildlife management area, including nearly 130,000 hectares (323,000 acres) in Polk, Lake, Pasco, Hernando, and Sumter counties; it was designated an "area of critical state concern" by the governor of Florida in 1964.

- Critical Habitat

Name	Location	Description
Manatee Habitat Designated by USDI (Federal Register 1975)	Hillsborough County: Little Manatee River downstream from U.S. 301 bridge. Manatee County: Manatee River downstream from Lake Manatee Dam Sarasota and Charlotte counties Myakka River downstream from Myakka River State Park DeSoto and Charlotte counties: Peace River downstream from Florida Highway 760 bridge Charlotte Harbor north of the Charlotte-Lee county line.	

- State Parks and Recreational Areas

Name	Location	Description
Highland Hammock State Park	Hardee-Highland counties 22 kilometers (14 miles) east of Zolfo Springs.	1,538 hectares (3,800 acres) including cypress and hardwood swamps, pine flatwoods, and oak and palm hammocks.
Hillsborough River State Park	Hillsborough County 16 kilometers (10 miles) north of Tampa.	1,200 hectares (2,964 acres) including hardwood hammocks and pine flatwoods.
Lake Kissimmee State Park	Polk County 23 kilometers (15 miles) east of Lake Wales	2,012 hectares (5,030 acres) of predominantly pine flatwoods and wet prairies, with scattered hardwood hammocks. Partly developed; not open.
Lake Manatee State Recreation Area	Manatee County 16 kilometers (10 miles) east of Bradenton.	222 hectares (556 acres) of predominantly pine flatwoods, with patches of sand pine scrub, hardwood hammock, and sandhills throughout. Partly developed; not open.

Name	Location	Description
Little Manatee River State Recreation Area	Hillsborough County 32 kilometers (20 miles) south of Tampa.	670 hectares (1,675 acres) in planning stage and not yet open. Habitat information not available.
Myakka River State Park	Manatee-Sarasota counties 27 kilometers (17 miles) east of Sarasota	11,686 hectare (28,875 acres), with 3,000 hectares (7,500 acres) of wilderness preserve. Habitat includes Myakka River floodplain, marsh, hardwood hammock, lakes, and prairie.
Oscar Scherer State Recreation Area	Sarasota County 16 kilometers (10 miles) south of Sarasota on U.S. 41.	187 hectares (462 acres) of riparian habitat (oak) along South Creek with planted and maintained pine flatwoods and slash pine-saw palmetto associations.
Port Charlotte Recreation Area	Charlotte County 16 kilometers (10 miles) west of Punta Gorda	98 hectares (245 acres) in planning stage and not yet open. Predominantly mangrove, with some hammocks.

2) Geological Areas

a) Aquifer Recharge Areas

The Green Swamp area, which extends northward from northern Polk County into Pasco, Sumter, and Lake counties (TI 1977e:Volume V, Plate 1), is an important groundwater recharge area in central Florida. A complex of ponds, lakes, pine flatwoods, many cypress swamps, and scattered marshes, wet prairies, and hardwood swamps, it forms the headwaters of the Peace, Withlacoochee, and Hillsborough rivers. A perched aquifer and associated Pleistocene dune systems are of special geological interest (Goodwin and Niering 1975).

The major streams and their tributaries, as well as many lakes, springs, and wetlands, form some of the most important landscape features in the study area; they are important not only for biological productivity but as flood-water storage areas, aquifer recharge areas, and pollution-treatment areas. Their water levels generally coincide with those of the water

table. The shallow water-table aquifer is hydraulically connected to the lakes and generally discharges into them; the lakes, in turn connected to streams as well as to the aquifer, provide base flow to the stream. The relationships of surface water and groundwater, as well as the general water quality and biological productivity of the water bodies, are discussed in Volume V (TI 1977e). Wetlands are discussed in Volume VI (TI 1977f).

Faults and fractures constitute a weak zone through which water can more easily percolate and produce solution cavities. In central Florida, faults are generally associated with the stresses caused during the formation of the Ocala uplift to the late Tertiary (although the faulting mechanisms may have continued beyond that time). Two main fracture patterns may be recognized (TI 1977f: Volume VI, Section 1 and Figure 2.8), with northwest-southeast direction fractures apparently more dominant than those running northeast-southwest. Both patterns extend into Hillsborough and Polk counties. In southwest Florida, surface manifestations of fractures are elongated lake regions and sinkhole collapses. Fractures are present in preferred zones of groundwater movement that are elongated areas of high-yield water wells. South of Polk and Hillsborough counties, the limestones that contain the fractures are more deeply buried by unconsolidated clastic sediments, limiting or obliterating their surface manifestation.

As mentioned in Volume VI, Section 1 (TI 1977f), limestone has vertical and horizontal seams and fractures through which water moves. Rainfall mixed with atmospheric carbon dioxide seeps into the ground and forms weak carbonic and humic acids that are natural solvents of limerock. The water percolates downward, usually along a horizontal bed or fracture; solution occurs, and cavities are formed.

The development of sinkholes is common in central Florida, but there is little probability of sinkhole development in Charlotte, Sarasota, DeSoto, and Manatee counties and most of Hardee County. The probability of sinkhole development is greater in Hillsborough County and portions of Polk County where well-developed sinkholes and solution depressions are present.

b) Flood-Prone Areas

For the purposes of this report, floods (a combination of rainfall and runoff) are limited to those occurring once in 100 years on the average. A 100-year flood, which is designated an "intermediate regional flood" by the U.S. Army Corps of Engineers, has a 1 percent chance of occurring during any year. The 100-year flood-prone areas of the larger streams are shown on Plate 2 of Volume V (TI 1977e). The lands shown are those immediately adjacent to the stream channels. Much of the study area is subject to shallow ponding and sheet flooding, which occur more often than 100-year floods.

Flood damage can include destruction of man-made features as well as vegetation along the stream banks and in floodway areas. Inundation can physically damage both urban and argricultural lands, transportation facilities, and utilities. Nevertheless, flooding is an important natural mechanism for depositing nutrients in the bottomlands, making them superior agricultural areas.

3) Effects on Sensitive Natural Areas

Effects on the sensitive natural areas are discussed in subsection C.1.b.1) (geological), C.1.b.2) (biological), and C.2.b (recreational).

2. Man-Made Environment

a. Land Use

1) Land Tenure, Public and Private

The term "land tenure," as used in the matrix, means the manner in which land is held. Although the matrix lists public and private tenure separately, most of the following remarks apply to both public and private tenure.

Most public land in the study area consists of wildlife refuges, parks, and other recreational areas. Ownership or use of this land will not vary greatly because public lands are subject to regulations regarding their

sale or use. The sale of surface mining leases does affect some federally owned lands in the study area. Lease sales do not involve land tenure changes, but the sale of leases and the subsequent mining of federal lands involve both tenure and land use change. Leasing, however, does not necessarily lead to mining; mining plans still are subject to county and state approval. Actually, few public lands will be vulnerable to mining. Most public lands are protected since they are recreational sites and wildlife refuges.

Currently, approximately 340 hectares (840 acres) of federal phosphate reserve lands in Polk County are being offered by the Bureau of Land Management. This amount represents only 0.2 percent of the study area. It must be emphasized that this is not a significant portion of the study area.

Tenure changes will occur more frequently on privately owned lands than on public lands. Although the former are more susceptible to tenure changes, their ownership in the 7-county study area will not change to a great extent within the planning horizon of the year 2000 because the phosphate companies have already acquired all but approximately 1,000 acres (1.5 percent of total area) of the land to be mined by the year 2000 (TI 1977c: Volume III, Plates 7 and 8). Although individuals who lease company-owned land may be displaced when a new tract is mined, tenure would not be interrupted.

After reclamation, the possibility of change in land tenure increases because land will have been converted to more "marketable" uses (e.g., citrus groves or improved pasture). In the study area, however, this will have no significant effect on land tenure.

2) Community and Regional Plans

The assessment of this impact will focus on the degree to which regional and community plans address phosphate mining and related activities.

TI previously identified the agencies responsible for land use planning on all governmental levels in the 7-county study area (TI 1977c: Volume III, Chapter 3, Section 2, pages 141-144); essentially, the required contents of local, government, comprehensive plans were outlined, providing the information necessary for effects assessment. If local governments are to meet state requirements, planning documents must consider phosphate mining and similar activities as part of several elements of their comprehensive plan, especially economic development. In the process of developing Volume III, Chapter 3 (TI 1977c), existing comprehensive plans were examined and planning officials in each county consulted. In addition, the essential elements of the land use plans and a map of future land use were incorporated in Chapter 4 of Volume III (TI 1977c).

Regional and community plans of the various governmental units within the study area are diverse. Given the diversity of basic values, concerns, and policies of different planning bodies, a certain amount of conflict in overall goals is inevitable. Fundamental conflicts are likely to continue among planning agencies and organizations.

Evaluating the phosphate industry's impact on community and regional plans is based on conflicts between industry activity and the plans. There is little conflict from a planning standpoint since the phosphate industry is addressed in most community and regional plans within the study area. Constraints on options for reclaimed land, however, must be noted as a problem affecting community and regional plans. Since land probably will not be returned to its previous use, land use projections (Corps of Engineers 1976) may not be realistic. More improved pasture and lakes ("land and lakes") will be created than any other land use type, and this situation certainly limits the options for future development.

3) Use Categories

Environmental demand elements in columns 66-72 should be considered identical to the land use categories of the U.S. Geological Survey used in Volume III, Chapters 3 and 4 (TI 1977c). Appendix 1 in Volume III defines these categories. The primary negative environmental effects of phosphate

mining on these land use categories involve actual destruction of the land use type and incompatibility of various land uses with nearby phosphate mining activities. As a positive effect, mining may result in the expansion of three land uses - residential, commercial, and industrial - that are closely tied to economic factors within the phosphate industry.

The primary information sources for land use assessment were the Four River Basins Area Economic Base Study (Corps of Engineers 1976) and the maps included in the Volume III chapters on existing and future land use (TI 1977e: Plates 5, 6, and 8). Another information source was the phosphate industry activity map's projections of areas of future mining (Figure 1.1 in this volume), which was used to calculate the amount of land mined in each scenario. Since the Four River Basins Study land use projections assumed continued growth of the phosphate industry, i.e., Scenario 2.11, "permit existing and new sources" (TI 1977c:Volume III, Appendix 2), acreages projected from it were adjusted to approximate the situation under Scenario 2.15, the "without action" alternative. The selection of Scenario 2.15 as the baseline necessitated converting 2.11 data to the assumption embodied in Scenario 2.15. The key difference between the two is the permit to mine new sources. Scenario 2.11 assumes that new sources will be permitted; Scenario 2.15 assumes that they will not be permitted.

The Four River Basins Study assumes that all the land within the boundaries of the permitted mines will be converted to a mining land use by 1985; by 2000, some of those mined lands will have been reclaimed to their previous use category. Examination of the land use rationale in the Four River Basins Study and consultation with land use planners in the study area result in the conclusion that the Four River Basins Study presents a plausible picture of Scenario 2.11.

Scenario 2.15 acreages were obtained by counting the acres in various land use categories within the boundaries of the pending-permit mines,

then adding those acres to the acres in that category in the 1985 Four River Basins Study. The assumption is that the Four River Basins Study has too many acres in mining and that those acres instead will remain in their 1975 use categories. Acreage adjustments appear in Table 2.12.

Table 2.12. Acreage Adjustments for Land Use Categories to Scenario 2.15 Baseline

	2.11 Hectares/Acres**		2.15 Hectares/Acres Adjusted	
Land Use Category*	1985	2000	1985	2000
Forests	55,095/136,138	58,785/145,255	56,568/139,778	60/258/148,895
Agriculture	425,844/1,052,246	426/780/1,054,560	430,632/1,064,076	431,568/1,066,390
Open space (includes USGS categories "Rangeland" and "Other Barren Land")	471,579/1,165,255	469,356/1,159,763	471,579/1,165,255	481,529/1,189/,843

*According to effects assessment matrix.

**Roy F. Weston (1976).

The 1985 acres under forest, for example, would be adjusted in the following manner for 2.15:

1985 Four River Basins	55,095/136,138	
	+ 1,473/ 3,640	acreage of forest within permitted mine boundaries
	55,568/139,778	= adjusted acreage for 2.15

Adjusting mined acres to conditions of the "without action" scenario presented a different adjustment situation from that of other land use categories. More specific information was available on approximate location and actual number of acres to be mined, particularly in the Development of Regional Impact (DRI) documents submitted by the mining companies seeking permits. The locations were outlined on a base map and designated as to time period (1976-1985 and 1985-2000) and scenario (2.15 and 2.11). The acreages are indicated in Table 2.13.

Table 2.13. 7-County Study Area Hectares/Acres Mined by Scenario and Year

Year	2.15	2.11
1985	13,702/33,856	22,819/ 56,384
2000	27,222/67,264	68,637/169,600

These outlines of mined areas were used to compute acres that mining would displace within certain land use categories. The number of displaced acres was compared with the overall change in acres in that category in the entire study area. Thus, a percentage of land use change attributable to mining was obtained as follows:

Acres displaced by mining	÷	Total change in that category between 1975 and 1985 (or 2000)	=	% of land use change attributed to mining

As mentioned previously, there are three land uses that would not, in all probability, be removed by mining, although scattered exceptions might exist. Each is discussed in more detail in the following paragraphs.

a) Residential Development

This category includes all residences except scattered farmhouses. Residential land use ranges from high to low density.

One difficulty in measuring the impacts of the phosphate industry on residential land use in the study area is that numerous other factors influence urban expansion, e.g., the growth of urban areas along the Gulf Coast from Tampa to Punta Gorda due in large part to "retirement home" establishment and the attractiveness of the coastal setting for outdoor activities. (Other population-growth stimuli pertinent to expansion of this land use are covered in this section's discussion of demography and economics.)

Residential land use may expand at a slower rate under the conditions of Scenario 2.15 than under 2.11. Quantification of 2.15 is dificult,

however, due to the multiplicity of factors affecting urban expansion. The Four River Basins Study, which assumes 2.11, projects 28 percent more acres in this category by 1985 and 51 percent more than at present by 2000 (TI 1977c:Volume III, Chapter 4, Table 2.1). The respective extents are 79,345 hectares (196,059 acres) in 1975, 101,860 hectares (251,693 acres) in 1985, and 119,696 hectares (295,764 acres) in 2000. In all probability, there would be fewer acres in residential land use under 2.15; the exact reduction, however, would not necessarily be in proportion to the drop in phosphate production.

Therefore, reliable quantification is impossible but a few generalizations can be made. For example, residential land use under 2.15 would increase more slowly in Polk County than in Sarasota County because of Polk's more direct effects from the phosphate industry; in fact, residential expansion under 2.15 in counties not containing pending-permit mines may be almost equivalent to that under 2.11. Another generalization is that transportation development will influence residential expansion. (The impact of phosphate mining on transportation is detailed elsewhere in this volume.)

Seldom is residential land use physically displaced by phosphate mining, but some adverse effects may be attributed to incompatibility when they are in close proximity. A "buffer zone" between residences and mining operations is one mitigative measure. (A more detailed discussion of incompatibility appears in this section under noise and visual degradation.)

b) Commercial Development

The method of evaluating effects on commercial land use is similar to that for residential use; again, little direct physical displacement will occur.

One direct effect of mining-related activities on commercial expansion is the construction of transportation lines to serve the industry. These railroads and highways serve as a magnet for commercial development. As in the case of residential land, the Four River Basins Study projections,

which assume 2.11, may approximate the 2.15 acreages due to the influence of other factors stimulating commercial development. Extents from the Four River Basins Study for commercial development are 8,739 hectares (21,593 acrs) in 1975, 10,144 hectares (25,0666 acres) in 1985, and 10,965 hectares (27,094 acres) in 2000. These may differ under 2.15 only in terms of distribution, not in total acreage.

Commercial land is more compatible than residential land with phosphate mining as evidenced by the commercial strip developments in the heart of the Polk County phosphate mining district along State Highway 60.

c) Industrial Development

Phosphate mining and processing activities are directly responsible for the creation and continued existence of some industrial land use in the 7-county study area. Not all industrial land, however, is linked to the phosphate industry; therefore, the acreage differences in this land use category will not be directly proportional to the lesser growth rate of phosphate production under Scenario 2.15, as compared with 2.11. The types of industry and the interrelationships between the phosphate industry and other industries in the study area are outlined in Volume III, Chapter 2 (TI 1977c: Table 5.1 and pages 90 and 91).

Again, assigning 2.15 acreage values to industrial projections is speculative; it may be said, however, that projections under the conditions of 2.15 will be less than those under 2.11 (16,329 hectares or 40,349 acres in 1985 and 15,561 hectares or 38,451 acres in 2000); the 1975 acreage is identical for both scenarios, i.e., 10,358 hectares (25,595 acres) (TI 1977c:Volume III, Chapter 4, Table 2.1).

Phasing out phosphate mining and processing would result in a decline in the amount of industrial land use in the study area. Some processing plants would continue to operate, however, since rock could be imported.

d) Mining

Information on acres presently being mined was derived from Four River Basins Study figures for 1975. Acres added under Scenario 2.15 (Table 2.14) were derived from the map of phosphate industry activity (Plate 1) and projected for 1985 and 2000.

Table 2.14. 7-County Study Area Mined Hectares/Acres Added under Scenario 2.15

1975*	1985**	2000**
4,603/11,375	13,702/33,856	27,222/67,264

*Four River Basins Study (1976).
**Industry activity map.

Some of the 1975 acres being mined will be reclaimed by 1985, and even more reclamation will have occurred by the year 2000. Reclaimed land will be returned to other land uses.

The Four River Basins Study acreage projections assume that land is essentially returned to its prior use, but field observations show that more land than indicated in the Four River Basins Study is returned to improved pasture and lakes. Additional information regarding reclaimed land are presented in the terrestrial biota sections of the impact statement.

e) Forests

Forest land is often difficult to define as a land use category unless a specific set of criteria is utilized. The USGS definition specifies a tree-crown areal density of 10 percent or more, stocked with trees capable of producing timber or other wood products and influencing the climate or water regime (TI 1977c:Volume III, Appendix 1). Tree plantations are not considered forest land. According to the Four River Basins Study, forest land covered some 172,000 acres in the study area in 1975.

The "without action" scenario projections were adjusted according to the methodology outlined in subsection B.2.a.3). Table 2.15 indicates the acreage projections and the percentage of overall study area change in forests because of mining.

Table 2.15. 7-County Study Area Hectares/Acres in Forests under Scenario 2.15

1975	1985	2000	Extent Mined	% Areawide Change Due to Mining
69,649/172,101				
	56,568/139,778		3,056/7,552	23
		60,258/148,895	4,843/11,968	52

Although a small amount of forest land is being reclaimed, the land use category as a whole is decreasing over the study area and phosphate mining is a major contributor (as indicated in Table 2.15) to its displacement. The impact of the elimination of a portion of this land use must be viewed in the context of its economic value, which is not substantial,* and in terms of its importance as a habitat supporting species important for hunting (i.e., recreational importance) and lending diversity to the composite of land uses in the study area. (The habitat aspect of forest land is covered in the terrestrial biota section of this volume.)

Forests are more compatible with adjacent mining activities than are many other types of land use categories. Forests adjoining mining operations provide an excellent "shelter belt" to buffer less compatible land uses from mining.

f) Agriculture

Agriculture as a land use category is broadly defined as land used primarily for production of food and fiber (TI 1977c: Volume III, Appendix

*Specific values do not exist, but field observations confirm this conclusion.

1). The USGS Level-II land use categories that include the majority of agricultural land in the study area are "cropland and (improved) pasture" and "orchards-groves." According to the Four River Basins Study, agricultural land comprised 1,128,563 acres in the study area in 1975.

As in the case of forests, the projections were altered to reflect the conditions of Scenario 2.15. These projections are presented in Table 2.16.

Table 2.16. 7-County Study Area Hectares/Acres in Agriculture under Scenario 2.15

1975	1985	2000	Extent Mined	% Areawide Change Due to Mining
456,729/1,128,563				
	430,632/1,064,076		3,937/9,728	15
		431,568/1,066,390	9,557/23,616	38

As in the case of forests, these statistics indicate that reclamation is occurring in the study area; especially, land is being reclaimed to improved pasture. However, total agricultural land is declining; and over the long term (year 2000), mining becomes an even more important factor in the decrease in total agricultural land. Displacement, however, will vary within the study area. The majority of mining-disturbed lands will be in Polk County and the Four Corners area. In Polk County, the most important citrus-producing county in Florida (Thompson 1976: page 247), citrus-crop acreage will account for much of the displaced agricultural land.

In evaluating the effects of the replacement of agricultural land by phosphate mining, the relative economic value (per land unit) ideally must be considered if the replacement is to be viewed in its proper perspective. Unfortunately, precise values are not available. Also, special consideration must be given to the impact of mining on prime and unique (a definition based on soil, climate, and slope characteristics [Didericksen

and Thompson 1976]) farmland because of the importance of its high productivity. Prime and unique farmlands and the effect of mining on them are covered in the soils section of this volume.

As in the case of forest land, agricultural land is compatible with adjacent phosphate mining lands and is a suitable buffer zone between mining and less compatible land use categories.

g) Open Space

The term "open space" as a land use category has varied meanings. As an environmental demand element in this assessment, it was deemed most appropriate to designate the USGS categories "rangeland" and "transitional areas" (TI 1977c:Volume III, Appendix 1) as open space. Other land use categories, especially recreational land, might have been appropriate to include in open space, but recreation was considered in another environmental demand element. "Transitional area" was termed "other barren land" by the Four River Basins Study, but both refer to land parcels for which remote sensor data do not allow inferring either former or future use. An example would be former forest lands cleared prior to development.

Acreages (1985 and 2000) from the Four River Basins Study were adjusted for Scenario 2.15 according to the previously mentioned rationale and are presented in Table 2.17.

Open space can function as an effective buffer between mining activities and more sensitive land uses such as residential. The economic value of open space is less noteworthy than its habitat and recreational value (discussed in more detail in the terrestrial biota section of this volume).

Table 2.17. 7-County Study Area Hectares/Acres in Open Space under Scenario 2.15

1975	1885	2000	Extent Mined	% Areawide Change Due to Mining
492,456/1,216,843				
	483,760/1,195,355		3,833/9,472	44
		481,529/1,189,843	6,682/16,512	62

4) Summary

The land use projections presented in Tables 2.15, 2,16, and 2.17 indicate that mining is a major contributor in the displacement of most categories of land use and that displacement due to mining will be greater in the year 2000 than in 1985 or 1975 despite land reclamation.

If displacement of land use categories is to be viewed in proper perspective, the economic effects must be considered. Also in assessing the impact of land use change, the value of land cover types as terrestrial habitat must be weighed. Other sections of this volume, especially those on demography and economics, provide this necessary information.

b. Archeological, Cultural, Historical, and Recreational

1) Archeological and Historical Sites

Numerous local, state, and federal regulations provide controls and guidelines regarding potential disturbance of archeological and historical sites because of their fragile nature and the probability of their being permanently altered or destroyed by mining (TI 1977c:Volume III, Chapter 1, pages 6 and 7). Archeological and historical sites evaluated in the effects assessment include all those mentioned in Volume III of the working papers (TI 1977c). The State of Florida Master Site File (Florida Division of Archives, History, and Records Management 1976) lists 791 sites within the 7-county study area. Although only 3 percent of the 791 are currently in the National Register of Historic Places, all could be considered eligible for inclusion in the National Register (TI 1977c: page 10) and therefore are appropriate to include in the effects assessment.

Differences in numbers of archeological and historical sites that would be affected under the conditions of Scenarios 2.15, 2.11 and 2.14A appear in Table 2.18. The numbers were determined by superimposing the map of site locations (TI 1977c: Plate 1) on the map of proposed mining areas (Plate 2 in this volume) and counting the sites which fell within the boundaries of proposed mined areas as "disturbed;" in most cases, they would be destroyed.

Table 2.18. Disturbed Archeological and Historical Sites*

Year	No. of Sites in Study Area	Scenarios 2.15	2.11	2.14
1985	791	6	11	1
2000	791	10	28	3

*Based on assumption of no additional sites discovered between 1976 and 2000.

The probability of destruction of sites within potentially mined areas is an issue which must be addressed. The Florida Division of Archives, History, and Records Management has expressed concern that valuable sites within the study area may be lost or suffer irreversible damage; the agency maintains that the negative effects will occur on a regional level and may result in the permanent loss of a sizable portion of Florida's archeological record (Florida Division of Archives, History, and Records Management 1976b). Mitigating measures include identification and preservation of potentially damaged or destroyed sites. Local, state, and federal regulations implement the basic protective measures (TI 1977c: Chapter 1, pages 6 and 7). Most regulations stipulate that projects requiring a governmental (local, state, or federal) permit include an assessment of the project's impact on these resources. For example, the Florida Department of Administration's DRI Guidebook requires documentation that a study was made "to determine whether or not any significant sites exist. If significant sites exist, the DRI applicant should provide details regarding their protection or preservation" (Florida Department of Administration 1976: page 29). The state historical preservation officer is the primary information source to determine significance of sites and to coordinate protection and/or preservation measures.

Another example of a mitigative measure to lessen impact on archeological and historical sites is the creation of a buffer zone between mining activities and the site itself. The most logical type of buffer is a "greenbelt" of land owned by a governmental agency with authority to control access.

Despite the mitigative measures to assure protection, many sites, especially archeological sites, may be destroyed even though the artifacts may be recovered.

Some positive effects will be created through the discovery of sites as a result of phosphate mining activities, but these positive effects will be offset by the destruction of sites. A balance between positive and negative effects is difficult to achieve. There is no way to devise a cost-benefit ratio because the number of new sites and their potential value cannot be anticipated.

2) Recreational Sites

Water-based recreational areas are those that support swimming, fishing, and boating. Effects assessment for the environmental element, water-based recreation, is based primarily on information contained in Volume III (TI 1977c) and Volume V, Chapter 2 (TI 1977e). Recreational sites in the study area are indicated in Volume III, Plate 2 (TI 1977c).

Among the potential negative effects of phosphate mining and related activities on water-based recreational sites situated outside the actual mining area are phosphate waste spills and, to a much lesser extent, reduction of surface water due to draining and dewatering. The largest spill of phosphate waste in recent history occurred on the Peace River in 1971 when a 102-kilometer (64-mile) stretch of the river was contaminated by the contents of a slime pond. All aquatic life was killed. A more recent example of wastewater spill, although of lesser magnitude than the Peace River spill, was in August 1977 on the Alafia River in Hillsborough County. One documented impact in this case was cancellation of canoe rentals of at least one private rental agency along the Alafia.

The short-term effects of phosphate mining on water-based recreation are almost entirely negative. They may be partially offset, however, by the creation of parks emphasizing water-based recreation by phosphate companies as part of their reclamation plans. An example of such reclamation

is Saddle Creek Park, which was dedicated to Polk County by Brewster Phosphate (TI 1977a: Table 3.6). Phosphate companies also have provided fishing and boating facilities on a controlled-access basis through private fishing and hunting clubs (e.g. IMC's "Fin and Feather Club"). The most important measure to mitigate the negative effects of wastewater spillage is enforcement of local and state ordinances regarding construction and maintenance of slime-pond dams and other wastewater holding systems and pipelines.

b) Land-Based

Land-based recreation includes all recreational activities other than those associated with water. Examples of important ones within the 7-county study area are hiking and camping, nature appreciation, and hunting. In Volume III (TI 1977c), these activities and their specific locations are discussed (Chapter 1, Section 3) and illustrated (Plate 2).

Reclamation's effects on land-based recreation are almost as important as those of mining itself. Although land-based reclamation might create limited recreational areas in which some land-oriented activities could be enjoyed, the replacement of wildlife habitat with improved pasture has a negative effect. This negative effect is discussed under terrestrial biota and land use in this section (2).

c. Demography, Economics, and Cultural Resources

1) Concept

Analyzing and assessing social and economic systems involve measurement of existing and future conditions, evaluation of a particular effect, and working combinations of the two. In each case, there is an attempt to balance the quantitative and qualitative analyses, although the relative weight of quantitative versus qualitative factors will differ from effect to effect.

Use of detailed effects assessment procedures graphically displayed in the matrix assisted in compiling, predicting, and assessing

relevant effects data. The reader should recognize that there was need for applying informed judgment, particularly in establishing underlying assumptions or in making conclusions from raw data. Some cases required that the person conducting the analysis exercise such judgment; in other cases, the combined socioeconomic study team interpreted the relative importance of a given finding or set of findings. Limitations were unavoidable and derived from a number of factors including the nature of the effects generated by phosphate industry operations, the difficulty in predicting future changes, and the frequent difficulty in finding agreement on the importance of such changes.

For each given variable shown on the matrix, three basic sets of questions were posed:

- Can the effect be quantified and measured?
- Is there general agreement as to the validity of prediction techniques? ... and can future changes be accurately predicted?
- Do clear standards or criteria exist with which to evaluate the severity or importance of predicted changes? ... and is there general agreement as to the validity of such standards or criteria?

When the answer to each question was yes, the effects assessment was relatively straightforward.

2) Anxiety Factors

Normally, public opinion is scientifically polled to reveal anxiety factors. In lieu of such polls, comments and editorials from local media were examined on a regular basis. While this was not a precise measure of public attitude, it was sufficient to give rise to the belief that the local populace is concerned about a number of possible effects from the phosphate industry and its operations. Although there may be no factual reason for these anxieties, they nevertheless exist. These concerns are that the phosphate industry will cause some or all of the following:

- Possibly increase air pollution through mining and manufacturing
- Possibly deteriorate water quality and decrease water quantity
- Increase radiation levels
- Increase noise
- Inflate land values
- Compete for increasingly scarce utilities
- Increase visual degradation

3) Effects on Community

a) Cohesion, Spatial Growth, Density, Diversity

Mining operations may intersect or bound a community, thereby possibly affecting the community's stability and cohesion. In assessing this possible effect, communities and their boundaries were identified and the stability of these communities then assessed using existing planning documents and other secondary data sources such as the U.S. Census.

The following are some of the key questions related to the assessment of the magnitude of incidence of change in the level of cohesion that could result from phosphate mining:

- Do identifiable communities exist within the mining operations area?
- Will the proposed mining intersect or isolate these communities?
- Will the mining affect the stability of a community by displacing or disrupting important segments of the residential or business community or by isolating segments of a community?
- Will the mining operations alter levels of community design cohesion through either the physical or psychological separation of residents or activities?

- Will the mining process itself affect community quality because of the presence of mining equipment, increased air and noise pollution, the need for vehicular and pedestrian detours, or other disruptive features?

- What identifiable groups (ethnic, age, income, occupation, etc.) will be adversely affected by mining operations?

As for spatial growth, the study area has become a crescent-shaped, urbanized zone from Lakeland to Tampa, curving south along the coast, with the central part of the study area held by the phosphate industry. Total population in the region by the year 2000 will not be significantly altered by any of the several alternatives. However, a decision to limit mining activities could discernibly affect future population density and diversity within the study area by making more land in the central portion available for urbanization or development.

b) Accessibility of Facilities and Services

Facilities and services include educational and health facilities; employment, commercial, and institutional centers; recreational and cultural facilities; and public utilities and emergency services (police, fire, etc.). Mining operations may modify accessibility to these facilities and services on either a local or regional scale. Locally, accessibility to facilities and services (e.g., police and fire protection) may diminish as a result of the barrier effect created by mining operations.

In the regional assessment, attempts were made to identify areas, facilities, and services affected by mining operations and to what degree they are affected. Also, possible effects on future levels of facilities and services were examined. The following were some of the key questions:

- Will the mining operations displace or alter the character of any major facilities or services?

- Will the mining operations reduce or hinder regional access to study area facilities and services by automobile or bus?

- Will any local groups or individuals experience a loss or reduction of access to community facilities and services as a result of the barrier effect of mining operations?

c) Population Displacement and Mobility

Property acquisition required for mining operations can displace people. Therefore, the probable magnitude of the displacement associated with the alternative must be assessed.

Mining and manufacturing operations also can affect population mobility: as operations are moved to new areas, some employees elect to commute to work rather than migrate in order to be closer to their daily work activities.

4) Man-Oriented Effects

a) Transportation

A consequence of relocating phosphate operations and creating the necessity for commuting is increased transportation problems.

b) Housing

Mining and manufacturing operations can affect residential activity, both the supply of housing and the demand for it, directly as well as indirectly. One concern in this assessment was the effect of residential property acquisition, which directly reduces the supply of housing and the construction of replacement housing. Also of concern are the indirect effects on locating new housing developments in the immediate area of the operations; phosphate mining operations can reduce the accessibility and attractiveness of vacant land, thereby potentially reducing residential activity.

c) Aesthetics and Cultural Opportunities

This effects category focuses on the man-made or man-oriented resources of the area and their interrelationships, human uses, and aesthetic and cultural value. To assess these effects, some key questions must be answered:

- What are the principal spatial characteristics and growth and activity patterns defining the physical setting of the study area?
- What aesthetic and cultural resources are found in the study area?
- Will the mining and manufacturing operations directly alter or induce the alterations of the physical form or character of the area?

5) Economic Factors

Since assessment of the effects of phosphate mining and manufacturing operations on economic resources must rest squarely on estimates and judgments regarding the economic activities that will be involved and the nature and scale of their involvement, the services of a trained economist were utilized. While this working paper expresses the effects in quantitative terms, it is important that the reader realize that the analysis was, for the most part, based on a series of judgments and assumptions.

Effects on economic development were measured in terms of employment, production, sales, income, and other economic indicators by analyzing the two broad classes of productive effort: basic activities, which are defined as those involving the exporting of goods and services to other areas; and nonbasic, or supporting, activities composed of goods and services consumed within the confines of the study area's economy. Basic activities are most directly affected by accessibility, since transportation is a vital aspect of their functioning; however, to the extent that basic industries (i.e., mining and manufacturing) are stimulated to grow, nonbasic industries will also grow to provide supporting goods and services. This effect was derived by using economic multipliers.

The effects (and analysis of impacts) of phosphate mining and manufacturing were examined in terms of the specific economic setting of the region, its resources, and its potentials. There is sound evidence that increases in phosphate mining and manufacturing induce employment growth in other basic sectors of the region's economy. These gains in basic economic activity, in turn, circulate through the supporting sectors of the economy by means of increased purchases by employees and export sales income. The effects reverberate or circulate among a wide range of economic sectors.

In analyzing regional phosphate mining and manufacturing effects, the following basic questions relating to the strength and liabilities of the existing regional economy were addressed:

- What are the sources of the regional economy's growth or sluggishness?
- What are the untapped potentials (and from whose viewpoint) in terms of natural resources, labor, and markets?

In essence, it was necessary to conduct a systematic analysis of the regional economy to determine which, if any, limiting factors are weakening the economy and causing available resources to be underutilized. As a minimum, the characteristics of the economy were examined in terms of three distinct categories:

- Employment opportunities and labor supply
- Production of goods and services
- Income and wages

The region's economic base, historic evolution, and strengths and liabilities were examined. Employment data revealed the relative importance of mining and manufacturing in the region vis-a-vis trade, agriculture, services, transportation, government, finance, insurance, and real estate. In addition, examination of employment trends within such specific sectors of the economy as the tourist and retirement industries highlighted these dominant sectors and their growth characteristics, locational attributes, and criteria. At the same time, past employment trends and employment

projections were evaluated to obtain an economic outlook for the region and a baseline for evaluating phosphate mining and manufacturing impacts.

d. Resource Use

For purposes of effects assessment, mineral resources include all naturally occurring material(s) accumulated as byproducts that are economical and/or beneficial now or as projected under the various scenarios through the year 2000. Resources of the 7-county study area are divided into three categories:

- Primary resources are those which, through depletion, result in a significant economic benefit
- Secondary resources are those for which significantly lower economic benefits are derived
- Tertiary resources are those requiring extensive technological development and/or significant changes in the current market.

In the study area, the only primary resource is phosphate (including uranium). (Because of the direct association of uranium with the phosphate, no attempt is made to assess uranium depletion separately [TI 1977f: Volume VI, Section 4]). Secondary resources include sand, gravel, timber, electric furnace slag, and limestone. Tertiary resources include but are not necessarily limited to sulfur (contained in the waste gypsum), gypsum, phosphate in the clay slime wastes, and aluminum from the aluminum phosphate zone. Under Scenario 2.15, the depletion of mineral resources is considered negative and is so shown on the accompanying environmental effects matrix. (This negative effect would be offset, however, by the economic benefits derived through the marketing of a given mineral or product developed from the mineral. The matrix includes such offsets under economics.)

Depletion of primary mineral resources constitutes a significant effect of the phosphate industry. Lesser significance is attached to depletion of secondary and tertiary resources. Timber resources are evaluated in terms of acres of forest lands which, as defined and mapped in Volume III, Chapter 4 (TI 1977c), contain deciduous, evergreen, and mixed forest lands. No attempt

is made to distinguish between these Level-II categories in terms of resource depletion or economics for effects assessment; rather, it is assumed that depletion of forest lands by clearing or burning in preparation for phosphate mining is a valid indicator of depletion of total timber resources and that economics can be linearly related. For example, if projected mining activities under one scenario indicate the potential disturbance of 50 percent more forest land than under another scenario, the depletion of timber resources for the former is also assumed to be 50 percent greater.

Since naturally occurring sand and gravel deposits in the 7-county study area are predominantly outside the phosphate industry's area of interest, the industry's activities have virtually no effect on their depletion. Because of the beneficiation processes employed by the industry, there is an abundance of relatively clean and uniform-size sand considered to be a mineral resource. However, there is no dominant market for these sands. Technically, waste slag produced from the calcination of phosphate rock also could be considered a mineral resource. Use has been made of this mineral, primarily as constituent road material, but is somewhat inhibited because of its radium-226 content (TI 1977f: Section 4). Limestone in the study area has been mined in small quantities, so its depletion as a resource is considered insignificant, especially if the vast statewide resources are considered. Also considered to be mineral resources in the area are sulfur (existing as gypsum waste at the chemical processing plants) and gypsum. At this time, there is no significant market for gypsum, and extracting sulfur from gypsum is technically feasible but not cost-competitive with imported sulfur. Alumina, which is contained in the aluminum phosphate zone, is also considered a mineral resource of the area; however, technical and cost/benefit problems currently inhibit its development.

The effects of phosphate industry activities on mineral resources under Scenario 2.15 are indicated on the accompanying matrix under column 24 and are discussed in the following paragraphs. Activities for which comments are not made have no effect on mineral resources.

1) Clearing (Line 4)

Land clearing constitutes total removal of vegetation, including marketable timber, from forest land. Approximately 3,056 hectares (7,552 acres) of forest land will be mined between 1977 and 1985 and 4,843 hectares (11,968 acres) between 1977 and 2000 under this scenario. However, the clearing of forested lands will have a negative effect on this mineral resource.

2) Burning (Line 5)

Normally, vegetative debris from land clearing in preparation for mining, which could include some marketable pulp wood, is burned. Decisions regarding the marketing of vegetative debris are considered site-specific. Since the loss of marketable wood through burning is considered minor, the effect on timber resources is not quantifiable.

3) Draglining (Line 6)

Draglining (dredging is germane under Scenario 2.11) physically removes phosphate (and uranium minerals) from the ground for subsequent removal to processing plants, thus depleting these mineral resources. Previously (TI 1977a:Volume I, Section 4) the study area's phosphate resources were disclosed to be $1,561.9 \times 10^6$ metric ($1,722 \times 10^6$ short) tons, including known reserves of 940.6×10^6 metric ($1,037 \times 10^6$ short) tons. The locations of current and future potential mining tracts from which a portion of these reserves and resources will be ultimately extracted are coded by scenario on the map (Plate 2) in the pocket. These locations are to show anticipated mining activities between 1977 and 2000. (For the distinction between reserves and resources, see TI 1977a:Section 4.) The effect of mining activities on the depletion of the area's phosphate resources is measured on the basis of percentage depletion of phosphate reserves rather than resources. This scenario is concerned only with current reserves.

is made to distinguish between these Level-II categories in terms of resource depletion or economics for effects assessment; rather, it is assumed that depletion of forest lands by clearing or burning in preparation for phosphate mining is a valid indicator of depletion of total timber resources and that economics can be linearly related. For example, if projected mining activities under one scenario indicate the potential disturbance of 50 percent more forest land than under another scenario, the depletion of timber resources for the former is also assumed to be 50 percent greater.

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The effects of phosphate industry activities on mineral resources under Scenario 2.15 are indicated on the accompanying matrix under column 24 and are discussed in the following paragraphs. Activities for which comments are not made have no effect on mineral resources.

1) Clearing (Line 4)

Land clearing constitutes total removal of vegetation, including marketable timber, from forest land. Approximately 3,056 hectares (7,552 acres) of forest land will be mined between 1977 and 1985 and 4,843 hectares (11,968 acres) between 1977 and 2000 under this scenario. However, the clearing of forested lands will have a negative effect on this mineral resource.

2) Burning (Line 5)

Normally, vegetative debris from land clearing in preparation for mining, which could include some marketable pulp wood, is burned. Decisions regarding the marketing of vegetative debris are considered site-specific. Since the loss of marketable wood through burning is considered minor, the effect on timber resources is not quantifiable.

3) Draglining (Line 6)

Draglining (dredging is germane under Scenario 2.11) physically removes phosphate (and uranium minerals) from the ground for subsequent removal to processing plants, thus depleting these mineral resources. Previously (TI 1977a:Volume I, Section 4) the study area's phosphate resources were disclosed to be 1,561.9 x 10^6 metric (1,722 x 10^6 short) tons, including known reserves of 940.6 x 10^6 metric (1,037 x 10^6 short) tons. The locations of current and future potential mining tracts from which a portion of these reserves and resources will be ultimately extracted are coded by scenario on the map (Plate 2) in the pocket. These locations are to show anticipated mining activities between 1977 and 2000. (For the distinction between reserves and resources, see TI 1977a:Section 4.) The effect of mining activities on the depletion of the area's phosphate resources is measured on the basis of percentage depletion of phosphate reserves rather than resources. This scenario is concerned only with current reserves.

It is anticipated that 327.4 x 10^6 metric (361 x 10^6 short) tons will be mined between 1977 and 1985 and 537.9 x 10^6 metric (593 x 10^6 short) tons between 1977 and 2000, representing a respective 34.8 and 57.2 percent depletion of currently known reserves and 21.0 and 34.4 percent depletion of resources, or -2 and -3 effect ratings for the periods defined.

4) Tailings Placement (Line 14)

Beneficiation processes in the study area result in the accumulation of large quantities of relatively clean and uniform-size quartz sand, which is technically considered a mineral resource. The balance between phosphate and waste quartz and clay minerals varies with locale (both within and between mines); however, if an average value of 50 percent sand is assumed (this would be a high for Polk County [TI 1977a: Table 3.3] but low for Hardee County [CF Mining 1973]) and combined with an assumed average of 25 percent slimes and 25 percent phosphate materials for all projected phosphate mining, there would be an annual accumulation of approximately 8.6 x 10^6 metric (9.5 x 10^6 short) tons of sand tailings.

This "created" mineral resource is valuable chiefly as a ready material for dike construction and land reclamation and to a far lesser extent as commercial sand. The beneficiation process thus has a positive effect on mineral resources, the degree being directly related to the tonnage of sand tailings accumulated.

5) Slime Placement (Line 15)

Clay slimes produced by the washing process contain phosphate materials which currently cannot be recovered economically. These fine-grained phosphate materials (along with the associated uranium) are returned to the mined areas. However, they are considered a mineral resource and are "available" for future recovery. Because of this preservation, slime placement has a positive effect on the area's mineral resources, with the magnitude being directly proportional to the tonnage and clay content of the mined ore processed through the washing plant. Economical recovery or

phosphate (and uranium) from clay slimes is not a foreseeable phosphate industry activity in the study area.

6) Waste (Phosphoric Acid Plant Gypsum) Placement (Line 22)

The accumulation of waste gypsum during phosphoric acid production is considered to have a positive effect on the total mineral resources of the study area. Waste gypsum is a potential source of gypsum and sulfur as well as other trace materials. Its accumulation at plants in the study area approximates 1.2 tons per ton of 30 percent phosphoric acid produced. The current annual production of phosphoric acid in the area approximates 5.4×10^6 metric (6×10^6 short) tons, which would result in the accumulation of gypsum at an annual rate approximating 6.5×10^6 metric (7.2×10^6) short tons.

Currently, there is no economical means of utilizing this mineral resource although a small quantity is sold locally, primarily as a soil conditioner. Therefore, a positive entry is made on the matrix for both the short and long terms.

7) Construction of Dams and Levees, Transportation Lines, Utility Lines, and Drainage Systems (Lines 24, 25, and 29)

Dams, levees, transportation lines, utility lines, and drainage systems are examples of the phosphate companies' use of land surface. In some cases (e.g., dams and levees), the use is permanent over the life of a particular operation (e.g., mining); others are only temporary (e.g., access roads). Where land within the boundary of a given mine is assigned permanent surface use, the underlying phosphate resources are preserved; thus, the effect on the overall mineral resources of the area is positive. Where land is assigned temporary surface use, the underlying phosphate minerals may be mined. Generally, however, permanent facilities within a mining area are located where the matrix is the least economical to mine because of overburden thickness or thin matrix bedding. Thus, while permanent life-of-the-mine surface land use preserves resources (a positive effect), the effect is considered to be negligible and a "0" is entered on the matrix.

8) Reclamation of Mining Pits (Line 31)

Reclamation techniques currently applied in the study area utilize waste tailings and overburden. This activity affects area mineral resources negatively in that the clean and uniform-size sand that could have commercial use is now mixed with overburden, reducing its value as a resource. Subsequent production of the resource would require rewashing and regrading On the matrix, then, the activity is given a sign and value opposite that assigned to tailings placement (accumulation) on Line 14.

9) Slime-Pond Reclamation (Line 31)

More than 20,235 hectares (50,000 acres) of slime ponds are estimated to exist for currently active mines. Reclamation of slime ponds using impoundment and natural settling techniques without sand mixing causes an accumulation of compacted phosphate clay, which is technically classified as a mineral resource because of its phosphate and uranium content. The reclamation of slime ponds would make it potentially available for reprocessing, but such recovery is not foreseeably feasible. Since the effects of this activity are to further the accessibility of slimes to remining, it is given a positive entry on the matrix.

C. SUMMARY OF PRIMARY EFFECTS

1. Natural Environment

a. Atmosphere

Under the constraints of Scenario 2.15, the chemical processing part of the phosphate industry will continue to operate at 1976 levels, supplementing domestic rock with imports as the existing mines are depleted. Because of the installation of air pollution control devices during 1976-77, there will be an immediate reduction of industrial emissions independent of any scenario projections; this will be most evident in the case of SO_2 emissions from H_2SO_4 plants in Polk and Hillsborough counties. Changes in the emission inventory due to restraints of the scenario will appear as reductions in dust as mining and drying activities decline. Emissions of SO_2 caused by fuel burning in the dryers will also decline as imports replace

locally processed rock. Since imports will supplant exports, it is estimated that the dust generated at seaports by movement of phosphate rock and refined products will remain at the same level.

The reductions in emissions (relative to 1976) are expected to reduce ambient SO_2 levels in Polk County, since no other source categories are predicted to increase enough to totally offset the decreases at the phosphate plants. However, particulate levels in Polk County and both SO_2 and particulates in all other counties in the study area should show a slight rise because of increases by nonphosphate sources.

The projected emissions for Scenario 2.15 (Table 2.19) include all major source categories in the study area. The inventories for 1974 and 1976 (TI 1977d:Volume IV, Section 2) were used as the starting point. The categories were broken down in detail sufficient to satisfy the data needs for impact evaluation using the algorithm discussed in subsection B of this section.

1) Area Sources

Area sources are primarily population-dependent, with fuel-burning (mobile and small stationary) and traffic-oriented emissions comprising the bulk of the area source emissions.

Area sources were projected from 1976 to 1985 and 2000 by assuming that any changes would be directly associated with population changes. University of Florida population projections were used (Thompson 1976).

2) Point Sources, Nonphosphate

Sources in this category were termed miscellaneous and divided into three groups - citrus, noncitrus, and electric utilities.

Table 2.19. Projected Emissions under Scenario 2.15

County	Category	Demand Element	TSP 1976	TSP 1985	TSP 2000	SO_2 1976	SO_2 1985	SO_2 2000
			Metric Tons per Year					
Charlotte	Area sources	–	1,862	2,953	4,961	147	234	392
	Point sources							
	Miscellaneous							
	Noncitrus	–	32	51	85	40	64	106
Total		–	1,894	3,004	5,046	187	298	498
DeSoto	Area sources	–	1,656	2,303	3,179	67	94	129
	Point sources							
	Miscellaneous							
	Citrus	–	29	29	29	85	85	85
	Utilities	–	0	0	4,678	0	0	185,315
	Phosphate							
	Mining/clearing	4	0	0	0	0	0	0
	Storage/transport	12	0	0	0	0	0	0
	Drying	13	0	0	0	0	0	0
Total			1,685	2,332	7,886	152	179	185,519
Hardee	Area sources	–	2,572	3,443	4,831	73	97	137
	Point sources							
	Miscellaneous							
	Noncitrus	–	23	30	43	5	6	8
	Citrus	–	15	15	15	109	109	109
	Phosphate							
	Mining/clearing	4	0	0	0	0	0	0
	Storage/transport	12	0	0	0	0	0	0
	Drying	13	0	0	0	0	0	0
Total			2,610	3,488	4,889	187	212	254
Hillsborough	Area sources	–	12,865	15,498	18,578	2,695	3,246	3,892
	Point sources							
	Miscellaneous							
	Noncitrus	–	1,815	2,186	2,620	7,539	9,083	10,887
	Citrus	–	2	2	2	16	16	16
	Utilities	–	3,831	6,816	7,835	213,218	222,932	233,645
	Phosphate							
	Mining/clearing	4	5	5	0	0	0	0
	Storage/transport	12	1,636	1,636	1,636	0	0	0
	Drying	13	87	155	155	307	729	729
	H_2SO_4	17	0	0	0	15,946	5,153	5,153
	Fertilizer	18	348	348	348	595	595	595
	Animal feed	19	104	104	104	1,029	1,029	1,029
Total			20,693	26,750	31,278	241,345	242,783	255,946
Manatee	Area sources	–	3,121	4,242	5,814	348	474	648
	Point sources							
	Miscellaneous							
	Noncitrus	–	132	179	245	118	161	220
	Citrus	–	164	164	164	0	0	0
	Utilities	–	276	2,211	2,211	3,801	30,407	30,407
	Phosphate							
	Mining/clearing	4	0	0	0	0	0	0
	Storage/transport	12	11	19	19	0	0	0
	Drying	13	0	0	0	0	0	0
	H_2SO_4	17	0	0	0	1,648	276	276
	Fertilizer	18	32	39	39	24	28	28
Total			3,736	6,854	8,492	5,939	31,346	31,579
Polk	Area sources	–	11,199	14,133	18,452	901	1,137	1,485
	Point sources							
	Miscellaneous							
	Noncitrus	–	586	740	966	318	402	525
	Citrus	–	436	436	436	625	625	625
	Utilities	–	295	965	965	6,981	13,695	13,695
	Phosphate							
	Mining/clearing	4	68	50	5	0	0	0
	Storage/transport	12	4,447	4,447	4,447	0	0	0
	Drying	13	1,178	864	78	7,581	5,559	505
	H_2SO_4	17	0	0	0	27,699	16,129	16,129
	Fertilizer	18	675	675	675	1,632	1,632	1,632
	Animal feed	19	106	106	106	40	40	40
	Elemental phosphorus	20	335	335	335	832	832	832
Total			19,325	22,751	26,465	46,615	40,051	35,468
Sarasota	Area sources	–	2,901	4,100	5,871	349	494	706
	Point sources							
	Miscellaneous							
	Noncitrus	–	114	162	232	175	246	354
Total			3,015	4,262	6,103	524	740	1,060

a) Citrus

These sources are primarily citrus processing plants. It is assumed for the purposes of air emissions that operations will continue at 1976 levels until 2000.

b) Noncitrus

This category includes all other point sources not specifically categorized. The types of sources included here are incinerators, asphalt plants, and manufacturers of other construction materials. These activities tend to be population-dependent and are expected to increase in direct proportion to the population.

c) Utilities

These sources are expected to operate under the same pollution control limitations existing in 1976. The following changes in capacity were used to project emissions:

- TECO
  - To add units 3 and 4 to Big Bend before 1985
  - To add a new plant on the bay near the Manatee-Hillsborough line
- FP&L
  - To have both Manatee units operational after 1977
  - To add a large plant (similar capacity to Big Bend) in DeSoto after 1985
- Lakeland Utilities
  - To add units 3 at Plant 3 in 1982
  - To retire Larsen unit 4 in 1983

3) Point Sources, Phosphate Industry

Phosphate industry point source emissions were broken down to correspond to seven of the technological demand elements in the effects matrix. Chemical processing is assumed to remain at 1976 production rates.

a) Mining/Clearing

Dust emissions in this category were associated with mining activities and varied directly with the projected rock production rate in each county.

b) Storage/Transportation

Dust generated in this category is expected to remain constant in Polk and Hillsborough counties and vary with the projected level of mining/beneficiation activity in other counties. Under Scenario 2.15, there is no projected activity (mining) outside of Polk and Hillsborough counties.

c) Drying

Emissions of SO_2 and particulates caused by the drying of wet rock are projected to track the level of mining activity in each county using 1976 as the base year.

d) H_2SO_4 Production

Emissions of SO_2 due to H_2SO_4 production are expected to remain constant until 2000 - but at levels lower than those reports in 1976 when all plants were not yet in compliance with emission regulations.

e) Fertilizer Production

Under Scenario 2.15, emissions in this category are assumed to remain constant at 1976 levels.

f) Animal Feed

Emissions from feed production are expected to remain constant until 2000.

g) Elemental Phosphorus Production

Emissions from phosphorus production are assumed to remain constant.

b. Land and Wetlands

1) Physical

a) Unique Physical Features

The natural physical features of the study area include the sand terraces, geologic ridges (e.g., the Lake Wales ridge), solution cavities (sinkholes) and partings of the surface and subsurface, and other minor features typical of flat, low-lying terrain. Of these, the ridges and solution cavities may be considered unique. Activities of the phosphate industry do not affect the ridges per se, but the industry can potentially effect sinkhole development and collapse. The primary effect is anticipated from loading the surface by creating large clay-slime storage impoundments and stacking waste gypsum. No data exist, however, to support quantification of the potential for collapse of a slime impoundment or gypsum stack. Seepage of low pH process waters through the waste gypsum stack, which potentially could serve to enlarge existing percolation pathways, is suspected but insufficiently documented to allow quantitative evaluation of the effects.

b) Soils

The phosphate industry activity that primarily affects soils is mining: it results in total disturbance of soil materials and horizons, destroying soils in terms of their original identification characteristics. Under Scenario 2.15, it is estimated that more than 4,850 hectares (12,000 acres) of soil associations rated as potentially high for agriculture will be disrupted by mining during 1977-85 and more than 8,500 hectares (21,000 acres) from 1977 through 2000. Once reclamation replaces the soil materials, however, new soils will develop that may be better suited for certain agricultural purposes because of improved moisture-holding capacity and permeability and the absence of underlying clay pans.

c) Exposure

The term exposure refers to exposure of the geologic section to study and analysis. Thus, industry activities that result in information about the geologic section, including its stratigraphy and geochemistry, constitute an irreversible positive effect. Principal among the activities are drilling and excavation. Under this scenario, these activities will continue through 1985 but will essentially cease by the year 2000.

d) Topography

Effects on topography are the result of industry activities that change natural surface contours, e.g., land excavation and the storage of materials (e.g., phosphate rock) or wastes (e.g., gypsum and clay slimes). Topography is primarily affected by excavations to remove phosphate ore. Estimates of the surface area to be mined under this scenario are 19,870 hectares (49,100 acres) during 1977-85 and 32,619 hectares (80,600 acres) from 1977 through 2000. Reclamation, however, will restore these lands to nearly their original contours.

e) Background Radiation

No new chemical processing plants or washing/beneficiation plants are forecast to be constructed under this scenario, so both the short-term (1977-85) and long-term (1977-2000) effects of ongoing industry activity on background radiation will be essentially concentrated in areas scheduled for mining during each of the periods. Exceptions would include the continued accumulation of waste products at the chemical processing plants, continued transportation of mine and processing plant products, and the ongoing construction of dams and levees and drainage control systems.

The effects of radium-226 radioactivity concentrations in materials associated with industry activities (Table 2.1) given in the attached table were estimated on the basis of change in surface materials (thus, radium-226 concentrations) geographically as a result of industry activities. Since mining exposes bedclays and residue matrix materials in areas

where the surface was previously native soil, the potential is to increase the "surface" radium-226 radioactivity concentration from 1.5 picocuries per gram to approximately 50 picocuries per gram. This negative effect is offset somewhat by backfilling the mining cuts with waste sand tailings (7.5 picocuries per gram) and overburden (10 picocuries per gram, excluding leach-zone materials). Areas of cuts dedicated to waste clay slime impoundments are expected to exhibit very low background radiation during the period when the slime particles (45 picocuries per gram) are covered with decant waters (1-2 picocuries per liter); however, as these areas dewater, background radium-226 concentrations in the surface materials are expected to approach the level given for slime particles. Thus, background radiation in reclaimed mined areas will be higher than prior to mining unless original surface materials are saved to top-dress both the reclaimed slime ponds and the lands containing the waste sands and overburden.

Under this scenario, background radiation at the chemical processing plants is expected to remain essentially at current levels until importation of phosphate rock is required to maintain production levels; then, background radiation should decrease with increased replacement of local rock by imported rock.

f) Noise

Under Scenario 2.15, noise levels will consistently decline with the phase-out of mining activities. Phosphate mining does not create noise levels high enough to represent an undesirable effect on area population not associated directly with the industry. Ambient noise levels will increase locally during mining and reclamation, especially in the immediate vicinity of operating bulldozers and draglines. Operations personnel can be easily protected from noise through administrative or engineering controls or the use of protective equipment. Thus, no effects are indicated.

2) Biological

There are five major effects of mining on uplands/wetlands biota:

- Certain existing plant communities are permanently displaced.
- As much as 30 percent of mined uplands/wetlands habitat becomes aquatic habitat.
- Habitat quality of unmined as well as mined land is degraded.
- Diversity is diminished.
- Local populations of many important species are reduced.

Approximately 21,052 hectares (52,000 acres) of uplands habitat will be mined by the year 2000 in currently permitted areas (Table 2.2). Forested habitat types are considered most important to the 7-county region (Table 2.3). Although estimates of evergreen forest are considered reliable, it is impossible to estimate present or future areawide extents of either mixed or deciduous forests, because data of appropriate detail are unavailable. Land use data presented by various phosphate companies in Developments of Regional Impact (DRIs) document the presence of some rather large parcels of these habitat types in projected mining areas (Table 2.4); they likely are present in areas currently being mined.

None of the forest types can be restored to their native condition on mined land. The deep sand soils necessary for mixed forests are irreversibly altered; the loss of an underlying organic hardpan precludes the reestablishment of typical pine flatwoods; and the configuration as well as species composition of hammocks is destroyed, although postmining soils, if allowed to revegetate naturally, will support similar communities. The 4,850 hectares (12,000 acres) of forest to be mined by the year 2000 represent more than one-half the areawide loss of the type by that time (Table 2.2).

Of less importance but still unreclaimable in its native condition is the extent [6,680 hectares (16,500 acres)] of mined rangeland. The [8,660 hectares (21,400 acres)] of agricultural habitat to be mined can be

considered temporary displacement, since reclamation is producing improved pasture primarily with smaller extents of plantations and parklands.

More than 2,990 hectares (7,400 acres) of freshwater wetlands habitat within currently permitted mining areas will be destroyed by 1985 and another approximately 2,140 hectares (5,300 acres) destroyed by the year 2000 (Table 2.2). This is a small (3 percent) but important portion of area-wide wetlands extent. There is no indication that wetlands of any kind can be restored on mined land. Not only are the low-relief topography and attendant drainage patterns of wetlands difficult to restore, but the deep, water-logged soils of many wetlands can be neither restructured nor feasibly conserved.

That the quality of terrestrial habitat generally reclaimed in mined areas is inferior is readily apparent when comparing wildlife usage of managed systems (pasture, cropland, plantation, and parkland) with that of essentially natural systems (dry prairie, forest). Unmined habitat also is affected by various activities of the industry: both plants and animals may be stressed by noise, dust, emissions (sulfur dioxide, suspended particulates, gaseous fluorides), moisture loss, and erosion, and animals particularly may be stressed by fragmentation of habitat. Although control devices apparently keep ambient levels of emissions and minor contaminants within acceptable state and federal air quality levels, habitat quality is not enhanced by the emissions standards and other standards, nor are optimum conditions ensured; habitat is allowed to degrade to the tolerance limits of both industry and the environment. Habitat fragmentation will have lasting effects, likely reducing the carrying capacity of the remaining habitat for wide-ranging herbivores (e.g., deer) and carnivores (e.g., bobcat).

The same factors that affect the habitat quality of uplands also affect the habitat quality of adjacent and nearby wetlands that are not mined. The effects of erosion and moisture loss may be greater in shallow wetlands than in uplands habitat. Mining into the shallow aquifer decreases the amount of soil moisture or standing water in adjacent habitat within 1,000 feet for 3 to 6 months, and wetlands vegetation damage is possible,

particularly during the wet season. Although erosion of mined land may be largely contained on the site, sediment load in streams increases and downstream wetlands receive part of the load, increasing turbidity and sedimentation.

Mining and subsequent reclamation are producing a more uniform habitat, reducing diversity of community structure in the region. The number of plants and animals in an area is directly related to the number of vegetation types (landscape-pattern diversity): as landscape-pattern diversity increases, so does floral and faunal diversity. The habitat types that are declining in the regional landscape are those of greatest individual diversity. The diversity within these types represents a greater variety of interactions among components (expanded food webs) and biological controls that tend to preserve an equilibrium. They can be maintained at no cost to man. To maintain agricultural habitat types as such (and particularly monocultures, which are the least diverse communities), it is necessary to use external controls such as pesticides, fertilizers, and, most pertinent to the concerns of the region, irrigation.

There are 12 threatened and endangered vertebrates that are likely to be adversely affected by mining (Table 2.9) and six others that may be affected, although their presence in the mining area is doubtful. Adverse effects, if any, on two species, the Osprey and Caracara, likely will be short-term - and the Osprey particularly may benefit in the long term. Two species, the Least Tern and Peregrine Falcon, both primarily coastal species, may be attracted to the mining areas; however, this is an outside possibility for the very rare falcon, which was last seen in the study area 3 years ago. Habitat loss is the primary threat posed by mining except in the case of the Wood Stork; this species utilizes suitable feeding sites on land to be mined but apparently does not breed on this land. Food supply of the Florida panther and Florida black bear also will be diminished, if indeed they do range over lands to be mined.

Commercial and recreational species will be variously affected by mining. The hunting potential for most waterfowl will increase because of

the creation of lake and pond habitat by mining (Table 2.10), but that of the other waterfowl species closely associated with woodlands and marshes will diminish. However, waterfowl comprise less than 10 percent of Florida's game bag; hunter effort is directed primarily (approximately 75 percent) toward only five species - deer, squirrel, dove, quail, and wild hog. The recreational potential of hunting quail and squirrel, which often occur on lands other than in management areas, will be reduced. Deer and wild hog habitat will be reduced, but the hunting potential probably will not be affected for these species since they are most often hunted in wildlife management areas. The potential for hunting the Mourning Dove, often hunted on private land, is expected to remain steady. The region's overall abundance of game will not be significantly affected, but continued habitat loss eventually will eliminate certain species from the game list and degrade the quality of hunting.

Mining will adversely affect more than one-half of approximately 75 ecologically significant species in the 7-county region. Most of these are closely associated with various natural or little-modified habitats, including wetlands and natural ponds and lakes that have gently sloped sides and wide littoral zones rather than the steep sides and narrow littoral zones of reclaimed lakes and ponds.

Mining activities will increase the potential of several species to reach population levels of nuisance or pest proportions. Mammal pests will proliferate around work areas and expanded urban areas. Bird pests will become more abundant in similar areas as well as on reclaimed pastures and croplands. Insect pests will proliferate around cattle, in areas devoted to monoculture, and in the nutrient-rich reclaimed lakes.

c. Water

1) Water Quantity

a) Methodology

A digital computer model (Wilson 1977) prepared, evaluated, and calibrated by personnel of the U.S. Geological Survey office in Tampa in

cooperation with the Southwest Florida Water Management District was used in assessing the effects of future pumpage from existing mines (Scenario 2.15) and existing and proposed mines (Scenario 2.11) on the Floridan aquifer. The model is a first attempt to simulate the complexity of the interrelationships of all the essential elements of the groundwater system in the Central Florida Phosphate Mining District. Therefore, the results should be considered as preliminary and subject to revision. The USGS is continuing the task of improving the reliability of the model. Within the time frame of the present study, however, the first model predictions are represented as approximate and are used only to estimate the effects of future groundwater pumpage by the phosphate mining industry on the potentiometric surface of the Floridan aquifer. Effects of the changes in total pumpage by the three major users of ground water (i.e., municipalities, agriculture, and other industry) are not predicted. Therefore, the partial effects on the potentiometric surface of the Floridan aquifer in 1985 and 2000 caused by changes in pumpage at phosphate mines exclusively cannot be compared with the effects of combined groundwater withdrawals by municipalities, agriculture, and other industry. This inability to compare effects is a distinct disadvantage in the effects assessment.

The digital 2-dimensional groundwater flow model simulates the hydraulic characteristics of the Floridan aquifer and its connection with the water-table aquifer through the overlying confining beds. [More detailed information is available in the USGS open-file report (Wilson 1977) from which this description is summarized.] The major assumptions upon which the design and operation of the model are based are as follows:

- Water in the Floridan aquifer moves in a single-layer isotropic medium.
- Water moves vertically into or out of the Floridan aquifer through the upper confining beds; no leakage occurs through the lower confining bed.
- The head in the water-table aquifer does not change with time or in response to any imposed stress.

The area within the model boundaries is approximately 5,854 square miles. A grid divides the area into nodal blocks ranging from 2 x 2 miles

to 8 x 2 miles and 6 x 6 miles. Each nodal area is identified by a row and column number. The model closely follows hydrologic boundaries and can simulate two types: a constant-flow boundary and a constant-head boundary. For the steady-state model calibration, a no-flow boundary was used.

The model incorporates two types of parameters: time-dependent and time-independent. The input and output parameters, which include pumpage (P) and/or recharge (R) and predicted changes in the potentiometric surfaces, are time-dependent. The oter parameters, which include transmissivity (T), storage coefficient (S), and leakance coefficient (K'/b'), are time-independent. The input parameter, or pumpage, consists of groundwater withdrawals for phosphate mining, chemical plants, other self-supplied industries, agriculture, and municiplaities. The input parameter, or recharge, is the amount of water that enters the Floridan aquifer from the overlying water-table aquifer. The amount of recharge is dependent upon the leakance and the head difference (Δh) between the potentiometric surface and the water table.

The model can simulate either dynamic (transient) conditions or steady-state conditions in the hydrologic system. Under steady-state conditions, the model simulates essentially a static water budget; in the transient state, it simulates a dynamic water budget.

The present model was calibrated under steady-state conditions. The entire groundwater system was assumes to be more or less in equilibrium (steady-state) at the end of September and the beginning of October 1975; at that time, there was apparent balance between pumpage, recharge, and observed altitudes of the potentiometric surface of the Floridan aquifer. The pumpage during that period is indicated in Table 2.20. It was assumed for the steady-state condition that in the September-October period no ground water was pumped for agricultural use.

The objective of the model calibration was to simulate as closely as possible the observed potentiometric surface in September 1975. During

Table 2.20. Groundwater Withdrawal for Phosphate Industry, Other Self-Supplied Industry, and Municipal Supplies, 1975*

Phosphate Industry				Other Self-Supplied Industry		Municipal Supplies	
Mines		Chemical Plants					
Node **	Mgal/d	Node	Mgal/d	Node	Mgal/d	Node	Mgal/d
3-23	4.85	5-18	0.63	3-29	0.37	2-26	0.57
3-24	6.47	6-19	25.57	4-15	0.10	3-27	0.26
6-9	0.82	6-22	3.50	4-20	1.20	4-16	0.37
6-21	0.36	6-23	5.47	4-21	0.70	4-17	1.48
6-23	7.59	6-24	9.21	4-26	5.09	4-19	0.57
7-19	20.10	7-9	45.00	4-27	5.50	4-21	2.86
7-20	5.97	7-19	3.86	4-28	0.65	4-22	3.42
7-21	0.23	7-21	2.16	5-11	0.03	4-23	1.71
7-23	6.74	7-22	14.32	5-28	1.50	4-26	0.78
7-24	15.10	8-23	3.69	6-9	0.58	4-27	1.34
7-25	6.99	9-22	1.42	6-26	4.10	4-28	0.54
7-26	7.72	9-25	14.36	7-31	1.00	4-29	2.16
8-23	14.94	12-7	5.80	8-28	0.20	5-12	3.60
8-26	19.38			8-31	1.45	5-19	1.14
9-20	7.36			14-25	1.28	5-20	0.57
9-21	1.09			17-26	0.03	5-21	1.71
9-25	16.64			19-6	0.65	5-22	2.28
9-26	10.70			26-23	0.23	5-23	1.14
9-27	0.36			27-30	0.10	5-24	1.14
9-28	0.14			29-26	0.15	5-28	1.63
10-22	2.29					6-12	0.96
10-25	12.14					6-25	2.64
11-22	5.74					6-26	0.75
						6-31	2.36
						7-11	1.79
						9-10	0.83
						10-9	3.04
						10-10	0.41
						15-26	0.91
						21-11	3.02
						21-12	4.08
						26-25	0.76
						30-8	0.77
						30-9	0.31
						31-8	0.07
						31-9	0.08
						33-10	0.78
						33-11	0.23
						33-18	0.18
Total (rounded)	174		135		25		53

*Adapted from USGS Open File (Wilson 1977).

**Refers to the location index used in the USGS digital model.

the calibration of the model, several adjustments were made in the various parameters.

Comparison of the observed and simulated potentiometric surfaces showed a similar pattern generally in the configuration of the potentiometric surfaces, but locally there were some major differences between the two. For example, the simulated altitudes of the potentiometric surface in the western half of Manatee and northern Sarasota counties were significantly lower than the observed altitudes in the same area. This was true also for the southwestern part of Polk County. The steady-state model appeared to overestimate the drawdowns in these areas, which could have been the result of the following factors: actual pumpage less than that entered in the model; leakance coefficients less than actual ones; transmissivity values less than actual ones; and possible proximity to the model boundaries. Magnitude and configuration of predicted water-level changes depend on the magnitude, duration, and areal distribution of pumpage, transmissivity, storage coefficient, leakance coefficient, and boundary conditions. The reliability of the predicted water-level changes is only as accurate as the validity of the least reliable parameter. The calibration process is, in a way, a reliability assessment.

Evaluation of results was made difficult because only the calibration results of the steady-state model and not the transient-state model were available. However, the predicted water- level changes were a result of transient-state model simulations.

The validity of each parameter was evaluated. The areal distribution and magnitude of the model parameters appeared to be not much different from those that might have been expected in reality, although some values of the leakance coefficient appeared to be on the low side. The magnitude and areal distribution of the transmissivity values were of major concern, especially the value of 80,000 square feet per day in the southwestern part of the study area. In reality, it seems reasonable to expect that the transmissivity should increase from north to south and from east to west. The author of the referenced report on modeling (Wilson 1977) was contacted and

indicated that the transmissivity distribution produced a fair match during the calibration process. In addition, he considered and tried other transmissivity values more along the lines suggested above but did not get a good match. The USGS is continuing to work on the calibration and will try other transmissivity values and distributions.

In summary, it can be said that the effects assessment is really an assessment of trends in the water-level changes in 1985 and 2000 for Scenarios 2.15 and 2.11'. The numbers quoted in this effects assessment are merely illustrative approximations and should not be interpreted as absolute results.

b) Primary Effects

The primary effects of groundwater withdrawals as described in Scenarios 2.15, will be expressed as a change in the potentimetric surface of the Floridan aquifer between September 1975 and September 1985 and between September 1975 and September 2000. The durations and pumping rates of all the mines and chemical plants to which Scenario 2.15 is applicable are presented in Figure 2.4.

Total pumpage for existing mines and chemical plants was 309,000,000 gallons per day in 1975 and 142,000,000 gallons per day in 1985, representing a decline of more than 50 percent. Groundwater pumpage for existing mines is expected to decline to 6,000,000 gallons per day in the year 2000, with chemical-plant pumpage remaining constant throughout the period. It was assumed in examining the effects of Scenario 2.15 that pumpage by agriculture and municipalities will be at the same level in 1985 and in 2000 as it was in 1975. The actual water-level changes can be quite different if the projected increase or decrease in agricultural and municipal pumpage is simulated in the model runs.

Model results showed that the potentiometric surface of the Floridan aquifer will generally recover in 1985. The greatest rise (approximately 10 feet) will be in Polk County just west of Fort Meade. The 5-foot

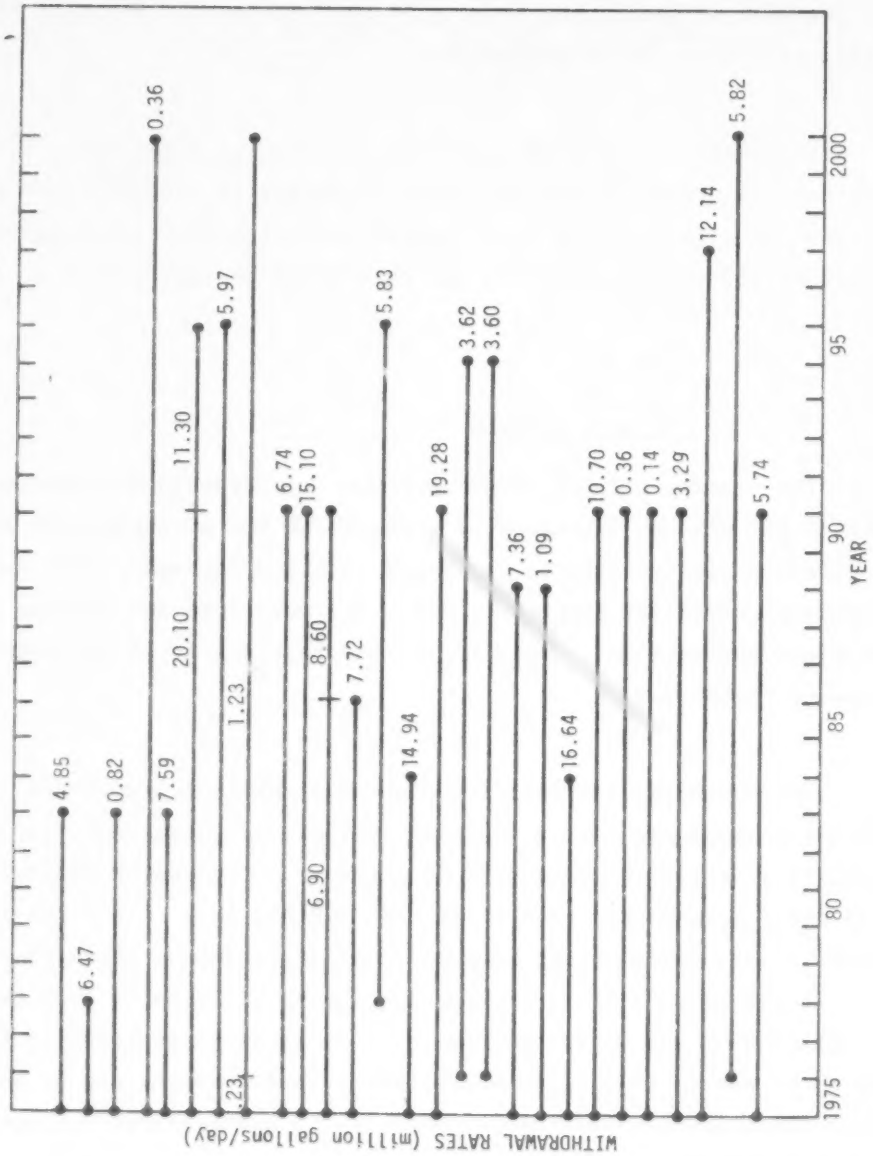


Figure 2.3. Projected History of Groundwater Withdrawals for Existing Phosphate Mines. (Data for life spans of mines from Texas Instruments Incorporated)

contour line indicates a recovery over a larger area between Bartow, Mulberry, Agricola, and Bowling Green. The 1-foot rise in the potentiometric surface will be in the southwestern part of Polk County, extending south of Lakeland, southwest of Winter Haven, north of Wauchula, east of Keys Field, and west of Bradley Junction. The no-change line runs approximately in a north-south direction, just east of the Hardee-Manatee County line and then swings northwesterly into Hillsborough County. The only decline predicted by the model was a 1-foot decline in the Fort Lonesome area. In general, the model showed no changes in the potentiometric surface of the Floridan aquifer in the study area except in southwestern Polk County and in southeastern Hillsborough County.

By the year 2000, nearly the whole study area will experience a rise in the potentiometric surface. The greatest rise, about 30 feet between 1975 and 2000, will be centered in an area northwest of Fort Meade in southwestern Polk County, extending southwesterly into Manatee and Sarasota counties. The model predicted a 1-foot rise in the potentiometric surface southwesterly as far as the center of Sarasota County in the Lake Myakka area and also in the western part of Manatee County.

2) Water Quality

a) Radiological

Kaufmann and Bliss (1977) summarized the radium-226 radioactivity concentrations in the waters of the water table and the upper and lower Floridan aquifers in the mined regions of central Florida (Table 2.21) using two data sets - one developed by the USEPA and the other by the USGS. The mean concentration of radium-226 radioactivity in the water-table waters of mined areas is given as 0.55 picocuries per liter; for the upper Floridan, 1.61 picocuries per liter; and for the lower Floridan, 1.96 picocuries per liter. The authors state that lower Floridan waters outside the mineralized area can have higher concentrations than those in mineralized areas, apparently because of natural processes unrelated to mining, and that existing water-table radium data indicate no significant difference between mined and unmined regions within the area of mineralization. However, local contami-

nation of ground water has occurred in the past and will probably continue in the future. Specific areas of concern include the large slime impoundments, the waste-gypsum stacks, and the large process-water cooling ponds. For comparison, Table 2.22 presents radium-226 radioactivity concentrations in ground waters of central Florida's mineralized but unmined areas and unmineralized areas.

Table 2.21. Radium-226 Concentrations in Ground Water in Mined Regions of Central Florida*

Aquifer		Picocuries per Liter EPA		USGS	
Water Table	No.	4		12	
	Mean	2.8		0.55	**
	SD	1.65		3.3	
	Range	2.0-5.3		0.20-4.40	
Upper Floridan	No.	No data		10	
	Mean			1.61	**
	SD			2.0	
	Range			0.16-6.0	
Lower Floridan	No.	6		7	
	Mean	1.86	**	4.49	
	SD	1.33		6.51	
	Range	1.3-3.5		0.14-14.0	

*Kaufmann and Bliss (1977)
**Author-preferred data
Note: Drinking water standard, 5 picocuries per liter combined radium-226 and radium-228.

Industry waste water effluents at the chemical processing plants contain soluble radium-226, but, according to Mills et al (1977):

> "To prepare process water for discharge to the environment, the pH must be increased from 1.5-2.0 to 6-9. To accomplish this, slaked lime is normally added to the discharge water in a step called 'double liming.' Our studies have shown that this treatment is highly effective in removing radionuclides from the effluent. Radium-226 reduction of greater than 96 percent was observed in all situations studied. Similar reductions in uranium and thorium were also observed."

In terms of radium-226 radioactivity concentrations, effluents (primarily slime decant waters) at the mines have been shown to be below drinking-water standards (in most cases less than 2 picocuries per liter). The interim effluent guide proposed by the EPA (USEPA 1974b) for the phosphate industry (phosphate chemical and fertilizer manufacturing) in terms of

Table 2.22. Radium-226 in Ground Water in Unmined Mineralized and Unmineralized Regions of Central Florida*

Region	Aquifer		Picocuries per Liter EPA	Picocuries per Liter USGS
Mineralized, Unmined	Water Table	No.	3	23
		Mean	1.63	0.17 **
		SD	1.65	12.9
		Range	0.2-3.3	0.05 - 22.0
	Upper Floridan	No.	9	5
		Mean	3.06	2.30 **
		SD	3.35	3.35
		Range	0.18 - 10.6	0.24 - 7.70
	Lower Floridan	No.	24	9
		Mean	2.0 **	1.4
		SD	2.3	1.3
		Range	0.19 - 15.3	0.06 - 4.7
Nonmineralized	Water Table	No.	No data	No data
		Mean		
		SD		
		Range		
	Upper Floridan	No.	No data	3
		Mean		5.1 **
		SD		4.3
		Range		0.2 - 7.9
	Lower Floridan	No.	14	2
		Mean	1.4 **	2.8
		SD	2.5	1.4
		Range	0.23 - 14.7	1.8 - 3.8

*Kaufmann and Bliss (1977).
**Author preferred data.

Note: Drinking water standard, 5 picocuries per liter of combined radium-226 and radium-228.

radium-226 is 9 picocuries per liter. However, efforts to achieve total recirculation of plant and mine waters are ongoing within the phosphate industry.

b) Other Water Quality Parameters

The primary effects on water quality because of phosphate industry activities under this scenario are (1) combined loadings of chemical pollutional parameters (especially phosphates, fluorides, and total suspended solids) from discharges of nonprocess and process wastewaters to stream segments A.1, A.2, A.4, A.5, A.8, A.9, A.12, P.1, P.4, P.5, A.7, A.8, H.1, and LM.1 (see TI 1977e:Volume V, Chapter 1, Section 2), (2) the creation of many water impoundments that will tend to deteriorate water quality by permitting overenrichment, (3) local surface-water deterioration from clearing, burning, construction, reclamation, slime spills, and seepage from contaminated ponds, (4) local water-table quality deterioration because of draining and dewatering, overburden placement, product storage, seepage from contaminated ponds, and reclamation of mining pits, and (5) local Floridan aquifer water quality deterioration from wastewater injection.

3) Biological

a) Areas Affected by Phosphate Industry Activities

Over the short term (1977-85), phosphate mining activities are expected to occur principally in southwestern Polk County and southeastern Hillsborough County. Aquatic habitat likely to be affected includes the upper portion of the Peace River, the upper reaches of Payne and Little Payne Creeks; Horse Creek, McCollough Creek, and the north and south prongs of the Alafia River. Riparian wetlands along portions of the Peace River and the north and south prongs of the Alafia also are expected to be disturbed, as are numerous small standing-water bodies and wet depressions characteristic of the region.

Over the long term (1985-2000), mining activities will be essentially limited to the same general areas described for short-term activities

and will continue to affect the water bodies discussed. Additionally, mining activities will expand into the upper portion of the Little Manatee River basin and farther down the Peace River in the vicinity of Bowlegs Creek.

b) Threatened and Endangered Species

Of the 13 aquatic species considered endangered, threatened, rare, or of special concern, only the American alligator (threatened; USDI), Suwanee cooter (threatened; FGFWFC, FCREPA), and manatee (endangered; USDI) might potentially be affected by phosphate industry activities in the study area. Land preparation and mining activities (particularly in the riparian wetlands bordering the Peace River and the north and south prongs of the Alafia River) will result in some loss of habitat and displacement of the American aligator but likely will have no adverse impact on the area's alligator population. These local disturbances could be offset by reclamation of gently sloped, shallow water bodies that would be appropriate habitat for the alligator. Over the long term, alteration of surface runoff patterns by mining activities and the creation of numerous impoundments during reclamation will alter the flow regimes of the Peace and Alafia rivers. The alterations will be of small magnitude, however, and are expected to result in only very minor effects on the Suwanee cooter and manatee through a potentially altered distribution of food plants.

The industry activity posing a potential for the most significant adverse impact on rare and endangered aquatic species of the study area is the placement of slime. Because of the long time interval required for the reclamation of slime ponds, increasing mining activity represents an increasing potential for adverse impact through spills resulting from dam failure and human error. A major spill would have substantial adverse effects on the American alligator, the Suwanee cooter (Alafia River only), and the manatee by disrupting the food chain. Although the immediate effects of such a spill are severe, the impact is reversible because stream ecosystems generally recover in 2 to 5 years (based on the magnitude of the spill).

c) Species of Commercial and/or Recreational Importance

Direct effects of industry activities will be limited principally to freshwater communities. Freshwater species of recreational and/or commercial value within the study area include largemouth bass, channel catfish, bream (bluegill and other sunfishes), and blue tilapia.

Short-term effects of mining activities on commercially and recreationally important species generally will be local and the result of land preparation and excavation, which alter habitat quality by changing local runoff patterns and increasing turbidity and siltation due to erosion. However, areas expected to be affected are small and only lightly utilized for recreational or commercial purposes.

A significant beneficial effect of phosphate mining activities on freshwater sport and commercial fisheries will be the increased acreages of surface water resulting from reclamation of mining pits. This additional surface water represents significant potential for establishing good commercial and recreational fisheries. If this potential is to be fulfilled, however, present reclamation must be altered to include lakes and ponds with wide littoral zones and other areas (e.g., "marshy" islands) that would increase habitat diversity and support a viable sport fishery. The steep-sided, relatively deep lakes now predominating are of little long-term value; they quickly become degraded and/or eutrophic.

Placement and containment of large amounts of slime resulting from mining activities represent a growing threat to recreational and commercial species of the study area. A major spill could devastate a river-based fishery for several years and, depending on location and magnitude, could also have significant adverse impact on estuarine fish and shellfish of recreational and commercial importance. Also, the economically important estuarine fisheries are susceptible to the long-term effects of modifying the flow regimes of major tributaries by altering drainage patterns and creating impoundments in mined areas. However, the magnitude of potential effects under this scenario (2.15) is considered small.

d) Nuisance and Pest Species

Categories of aquatic nuisance and pest species that are expected to be affected by phosphate industry activities in the study area include exotic hydrophytes (hydrilla, water hyacinth, etc.), algae (principally filamentous green and bluegreen forms), midges and mosquitos, Asiatic clams, native nuisance fishes (bowfin, gar, gizzard shad, etc.), and exotic fishes (walking catfish, blue tilapia).

Draining and dewatering low, wet areas will result in a positive effect by eliminating breeding areas for midges and mosquitos, but this will be more than offset by the phosphate industry's creation of additional surface water; the new surface-water impoundments, if not properly managed, can potentially lead to nuisance algae and aquatic hydrophytes and increase the number of midges and mosquitos and undesirable fishes.

e) Standing-Water Communities

The standing-water or "lentic" aquatic communities of the study area comprise natural and man-made lakes and impoundments, ponds, pits, and seasonally wet depressions. Except for some interconnection of lowland wet areas, the standing-water communities represent rather discrete ecosystems. Thus, the effects of phosphate industry activities on standing-water communities, unlike those on flowing-water communities, are highly localized.

The amount of standing-water communities expected to be directly affected by phosphate industry activities under Scenario 2.15 is relatively small and involves no major lakes, ponds, or impoundments. Effects on the smaller standing-water bodies in the study area will result principally from alteration of runoff patterns and increased siltation from erosion of cleared areas. Land preparation and mining excavation also may directly disrupt standing-water communities.

Perhaps the most important consideration relating to industry effects on standing-water communities will be the creation of new standing-water habitat. It has been projected that approximately 7,280 hectares

(18,000 acres) of mined land will be reclaimed to lakes between 1977 and 1985; by the year 2000, this area will be approximately 11,490 hectares (28,400 acres). This area, if properly reclaimed and managed, represents a considerable increase in resource potential for sport and commercial fishing, but utilization of this potential fishery is expected to be relatively light since an outstanding marine fishery is also readily available to anglers.

f) Running-Water Communities

Of the three basic aquatic community types described for the study area, the running-water communities (streams and rivers) will experience the greatest effects from phosphate industry activities. Under Scenario 2.15, approximately 14,130 hectares (34,900 acres) of land will be mined by 1985 in the upper Peace River Basin, approximately 120 hectares (300 acres) in the Little Manatee River Basin, and 5,830 hectares (14,400 acres) in the Alafia River Basin. By the year 2000, disturbed surface acreage will increase to approximately 31,000 hectares (76,600 acres) (19,500 hectares [48,300 acres] in the upper Peace River Basin; 1,417 hectares [3,500 acres] in the upper Little Manatee River Basin; and 10,000 hectares [24,800 acres] in the upper Alafia River basin). This magnitude of activity will measurably affect runoff patterns and flow regimes of headwater streams within the three river basins and, to a lesser degree, flow regimes of the Peace, Alafia, and Little Manatee rivers. Local alterations of the flow regimes of smaller tributaries may be severe, but effects on the flow regimes of these three major rivers will be minor and will be obscured in normal flow variations.

Another important factor affecting the flow regimes of streams in the study area will be the creation of large acreages of impoundments that result in loss of runoff water to the streams and a net loss of surface water from the area through evaporation. It has been projected that decreases in discharge attributable to evaporation losses of impounded water in the Peace River Basin will be equivalent to about 15 cubic feet per second by 1985 and 21 cubic feet per second by the year 2000 in the Peace River, 6 cubic feet per second by 1985 and 11 cubic feet per second by 2000

in the Alafia, and 0.1 cubic foot per second by 1985 and 1.5 cubic feet per second by 2000 in Little Manatee. Average flows near the mouths of the Peace, Little Manatee, and Alafia rivers are 1,195; 175; and 373 cubic feet per second respectively.

The total effect of phosphate industry alteration of the flow regimes of streams in the study area through 1985 will be minor; however, by 2000, the magnitude of alteration will be sufficient to cause some noticeable community shifts from rheophilic organisms (those preferring flowing water) to those more indicative of lentic or standing-water habitats. This will represent an adverse effect, since flowing-water communities are of greater resource value to the study area.

In addition to affecting the flow regimes of local streams, phosphate industry construction, land preparation, and excavation will cause some local degradation of stream habitat quality by increasing siltation and turbidity. However, such adverse effects are expected to be local, rather short-term, and only minor from a regional perspective. Community-structure alterations accompanying local habitat degradation by siltation and turbidity will be manifested as reduced algal abundance (benthic and periphyton communities), replacement of more desirable benthic forms (e.g., mussels, odonate, and mayfly naiads) with forms more tolerant of silty substrate (tubificid worms, diptera larvae), reduction in condition of local fish populations through disruption of the food chain, impairment of feeding activities, and reduced fish egg and larva survival.

g) Bay and Estuarine Communities

The effects of phosphate industry activities on bay and estuarine communities of the study area will be limited principally to the long-term effect of mining activities on freshwater discharge patterns of the Peace and Alafia rivers (discussed in the preceding). Changes in freshwater discharge will alter salinity regimes within the river estuaries and thus will affect distributions of estuarine organisms. However, the effects of the relatively small changes of freshwater discharge patterns are expected to be minor and obscured in normal discharge variations.

2. Man-Made Environment

a. Land Use

The major impact of phosphate mining on land use in the study area is the displacement of acres in the various land use categories. Forest land, agricultural land (USGS Level-II categories "cropland-pasture" and "orchards-groves), and open space (USGS Level-II categories "rangeland" and "transitional areas") will be displaced (Table 2.23), while other land uses (residential, commercial, and industrial) will be affected areally through the economic stimulation of mining activities but will not be displaced because of their relative economic values. As an example, residential land may expand in certain areas (other than immediate mining areas) over time because of the influx of population stimulated by the presence of phosphate mining and related activities.

Table 2.23. Displacement Areas, 1985 and 2000 (Scenario 2.15)

	Areas (hectares/acres)				
	(a)	(b)	(c)	(d)	(e)
Land Use Categories (keyed to matrix elements)	Four River Basins, Unadjusted	Adjusted	1975 Unadjusted	Area Mined According to Map	Difference (c-b)
Forests	55,116/136,138	56,590/139,778	69,676/172,101	3,057/7,552	13,086/32,323
Agriculture	471,763/1,052,246	430,800/1,064,076	456,908/1,128,563	3,938/9,728	26,108/64,487
Open space (includes USGS categories rangeland and other barren land	471,763/1,165,255	483,949/1,195,355	492,648/1,216,843	3,834/9,472	8,699/21,488
Forests	58,807/145,255	60,281/148,895	69,676/172,101	4,845/11,968	9,395/23,206
Agriculture	426,947/1,054,560	431,736/1,066,390	456,908/1,128,563	9,561/23,616	25,171/62,173
Open space (includes USGS categories rangeland and other barren land)	469,539/1,159,763	481,717/1,189,843	492,648/1,216,843	6,685/16,512	10,931/27,000

Compatibility of the various land uses with phosphate mining varies. Residential land is the least compatible of all categories; on the other hand, forests and open spaces provide excellent buffer zones between mining and less compatible land uses. There will be more disturbed acres of forest, agriculture, and open space by the year 2000 than by 1985. By 2000, reclamation will have increased acreages in each of the mentioned categories

over 1985 acreages but will not have restored them to their 1975 extents. Projections of the Four River Basins Area Economic Base Study as summarized in Table 2.23, are not realistic since most reclaimed land probably will be returned as improved pasture and lakes. Planners (and land use plans) in the study area, most of whom agree with the fundamental philosophy of the Four River Basins Study, may have unrealistic expectations for potential uses of reclaimed land. Placing additional constraints on the variety of future land use are existing laws and regulations specifying physical requirements for reclaimed land.

Mining will not adversely affect land tenure, either public or private, since mining companies already own almost all land that will be mined through the year 2000.

b. Archeological, Cultural, Historical, and Recreational

Areas to be mined in the future, as projected on the map "Relationship of Phosphate Industry Land Use Management Projections to Present Land Use" (Plate 2 in pocket), contain historical and archeological sites.

The number of sites that will be disturbed (by scenario) is listed on Table 2.18, which appears in subsection B.2.b of this section.

Most archeological sites are extremely fragile and would be permanently altered or destroyed if mined. Florida's Division of Archives, History, and Records Management (1976) has expressed concern that valuable sites within the study area may be lost or may suffer irreversible damage; this agency maintains that the effects will occur on a regional level and may result in the permanent loss of a sizable portion of Florida's archeological record. Unless measures were taken to collect and preserve the artifacts prior to mining, the state office's concerns would be valid.

As far as existing and potential recreational areas are concerned, phosphate mining will have both positive and negative effects. Water-based recreation is particularly sensitive to wastewater spills. Such spills,

especially the one on the Peace River in 1971, can be extremely destructive (Blakey 1973). One land-based recreational activity, hunting, will be affected not only by habitat destruction due to mining but also by the reclamation of mined lands to improved pasture, the creation of which does not restore habitat. Reclamation can provide additional recreational areas, however, and should be planned with care to provide an aesthetic setting. Polk County's Saddle Creek Park is an example of the creation of recreational areas and their dedication to local governmental units.

c. Demography, Economics, and Cultural Resources

One should be aware that all official population and economic projections that have been examined during the course of this study are based on the postulation of continued development of the phosphate industry in the study area. Attention is invited to Plate 3 in Volume III (TI 1977c) that shows the 1975 density of population projected to 2000 and to Plate 7 in the same volume that shows industry locations (mines, processing plants, and pending permits). One can easily see that the phosphate industry's existing ownership of large tracts of land on a north-south axis from Lakeland to Port Charlotte has probably been the major cause of the current crescent-shaped population concentration from Lakeland to Tampa and along the coast to Port Charlotte.

Land use in the northern part of Polk County has been dramatically affected by the Disney World entertainment complex (just north of the Polk County line). Land values for residential and associated commercial development and tourist accommodations have increased at a tremendous rate in recent years, resulting in significant land use changes. For example, land devoted to growing citrus has been removed from production and shifted to intensive development.

Without the increased phosphate mining activities in Polk and other counties, existing land use in those areas could undergo great changes in character. Specifically, the phosphate industry would probably turn back (sell) much of its large land holdings if not allowed to expand mining; this land would then be available to reduce population concentrations.

Table 2.24 shows the projected economic impact of the phosphate industry on the study area by scenario. The "Without Action" alternative would mean a loss of 2,674 phosphate industry jobs in 1985 and a loss of 7,554 jobs by the year 2000. Phosphate industry payroll losses would be $20,700,000 in 1985 and $58,500,000 annually by the year 2000. One can see that losses in employment and payroll by phosphate industry-induced industry and business would be much greater.

Since the service businesses catering to the needs of the retirement and tourist sectors are in direct conflict with the phosphate industry, there is good reason to believe that they could absorb surplus workers from the phosphate industry.

The effects of the "Without Action" alternative also can be better understood if one understands the existing transportation network and plans.

The study area is served by all modes of transportation. Trackage at Tampa Harbor connects to the Seaboard Coastline Railroad System. Two interstate highways, I-75 and I-4, along with other federal and state roads, connect the study area with other parts of Florida and the United States. Interstate 75 is scheduled to be constructed south along the Gulf Coast through the study area to the Florida east coast. Tampa International Airport, which is served by 10 major airlines, provides domestic and foreign service. Numerous shipping lines and barge lines have facilities in Tampa Harbor and provide extensive service to waterborne commerce. Major plans are now underway to improve Tampa Harbor.

Tampa is a major port and vital to the economics of Florida as well as the nation. On a total tonnage basis, it is now the fourth largest export port and the eighth largest U.S. port. Annually, it handles more than 40,000,000 tons (36.3×10^6 metric tons) of commerce valued at more than $490,000,000. Its export exceeds 11,000,000 tons (10×10^6 metric tons) valued at more than $172,000,000. Phosphate shipments represent 97 percent of the port's outgoing cargo, and sulfur for the phosphate fertilizer industry represents an almost equal percentage of incoming cargo. A

Table 2.24. Projected Economic Impact of Central Florida Phosphate Industry from Domestic Mining Only on Study Area by Scenario, 1980-2000#

Year	Scenario	Production (million short tons)	Phosphate Industry Employment*	Phosphate Industry Payroll** (000,000)	Induced Employment***	Induced Payroll**** (000,000)
1975	Actual†	38.2	8,512	65.8	52,349	221.3
1980	2.11‡	41.2	9,181	71.0	56,463	238.7
	2.15‡	42.2	9,403	72.7	57,828	244.4
1985	2.11‡	45.2	10,072	77.9	61,943	261.9
	2.15‡	33.2	7,398	57.2	45,498	192.4
1990	2.11‡	44.8	9,983	77.2	61,395	259.6
	2.15‡	27.5	6,128	47.4	37,687	159.3
1995	2.11‡	42.0	9,359	72.4	57,558	243.4
	2.15‡	9.1	2,028	15.7	12,472	52.7
2000	2.11‡	36.5	8,133	62.9	50,017	211.5
	2.15‡	2.6	579	4.4	3,560	15.0

*Based on 1975 average of 222.84 workers per million tons produced.

**Based on 1975 average of $7,742 per worker per annum, 1967 constant dollars.

***Based on Bureau of Mines estimates of 6.155 jobs generated for each new job in the phosphate industry.

****Average of $4,228 per worker per annum, 1967 constant dollars.

†U.S. Bureau of Mines (1975) adjusted by Texas Instruments for the study area; Florida Statistical Abstract (1976).

‡U.S. Bureau of Mines (1977) adjusted by Texas Instruments.

‡‡Texas Instruments projections of production from existing mines.

#To estimate total projected impact, effects from constant employment of about 3,000 chemical processing plant employees must be added.

major part of the economic justification for improving Tampa Harbor is the favorable economic impact expected on phosphate shipments. In the 8-county area around Tampa Harbor, one in every seven wage-earners is employed by port-related businesses; this amounts to more than 36,000 workers and an annual payroll exceeding $210,000,000. Without the scheduled harbor improvement and concomitant increased phosphate industry shipments and receipts, the port could a decline in importance, reflecting adversely on the regional economy and ultimately changing the character of current development.

d. Resource Use

Phosphate industry activities that affect natural resources of the area are focused on depletion of not only phosphate but uranium and, to a lesser extent, timber. Because uranium is mined concurrently with the phosphate, no attempt is made to assess its depletion separately. Timber, however, is treated separately.

Clearing land in preparing to mine phosphate involves the total removal of vegetation, including marketable timber. It is estimated under this scenario that approximately 3,056 hectares (7,552 acres) of land mapped as forest land will be mined during 1977-85 and 4,843 hectares (11,968 acres) between 1977 and 2000.

Phosphate resources of the area are estimated to be $1,561.9 \times 10^6$ metric ($1,722 \times 10^6$ short) tons; 940.6 metric ($1,037 \times 10^6$ short) tons are classified as known reserves. Under Scenario 2.15, it is forecast that 327.4×10^6 metric (361×10^6 short) tons will be mined during 1977-85 and 537.9×10^6 metric (593×10^6 short) tons from 1977 through 2000. This represents a reserves depletion of 34.8 and 57.2 percent respectively.

D. SUMMARY OF SECONDARY EFFECTS

1. Natural Environment

a. Atmosphere

No secondary effects were quantified under this heading.

b. Land

1) Physical

a) Unique Physical Features, Exposure, Topography, and Noise

No secondary effects of significance were noted for these environmental elements.

b) Soils

Secondary effects of phosphate industry activities on soils are primarily restricted to the chemical alteration of soils resulting from the stacking of materials. This includes the wet rock storage piles and the gypsum stacks at the chemical processing plants. Water percolation through these materials tends to cause them to leach and be subsequently deposited in the soil underlying horizons. No secondary impacts could be determined for the various scenarios, however, because of the lack of any quantitative model with which to assess the effects of this leaching. The number of gypsum stacks is assumed constant among scenarios, but new wet rock storage piles are anticipated under Scenarios 2.11 and 2.11' (Section 3).

c) Background Radiation

Although there has been no proof to date that any activity of the industry causes a radiation impact on the general population, there are four potential pathways for secondary impacts of exposure:

- Air contamination by radionuclides associated with dust created when dry phosphate rock and phosphate products are transferred

- Possible contamination of ground waters by seepage of process waters at the chemical plants and slime-pond waters in the mine areas

- Radon-222 daughter product contamination of air in structures built on land previously mined by the industry

- Consumption of foods (crop foods or beef) produced on reclaimed lands

Of the above, exposure from radon-222 daughter radionculides in homes or other structures built on reclaimed land is considered the most significant.

Quantifying impacts on the general population due to exposure associated with the pathways just listed is considered beyond the scope of this program.

2) Biological

The reader is referred to the discussion of primary effects in subsection C.1.b)2). Among possible secondary effects not implied in that discussion are certain changes occurring in coastal areas as a result of mining activities. For example, if the harbor area were increased to accommodate the transportation of phosphate rock or other materials, it could affect terrestrial biota; however, the expected changes (e.g., the deepening of Tampa Bay), will have little effect.

c. Water

1) Water Quantity

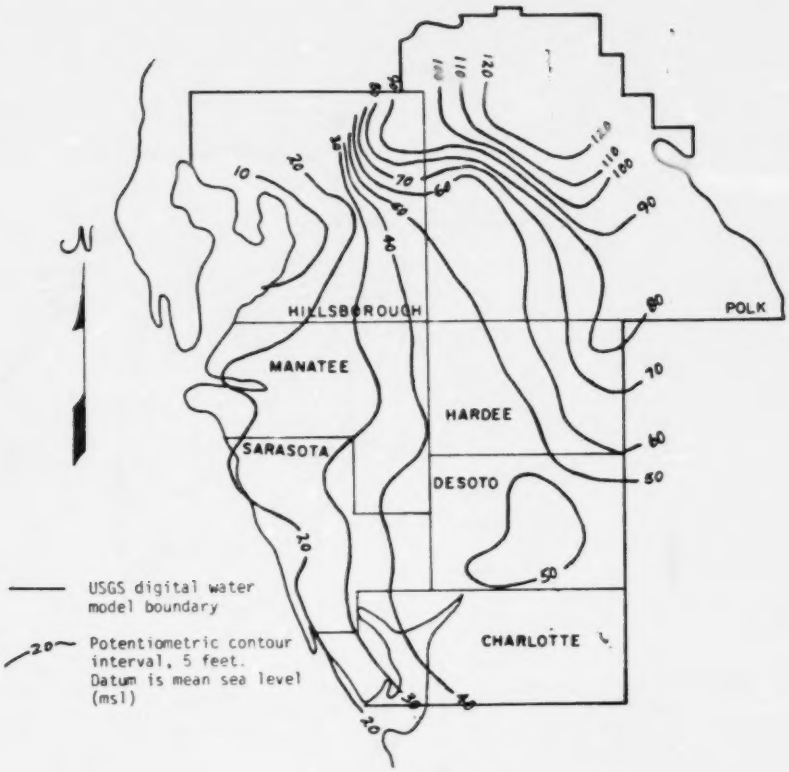
The major areas of concern are that pumping from the Floridan aquifer will (1) decrease stream flow, affect surface vegetation, and possibly affect lake levels and (2) cause upconing of highly mineralized waters from the deeper parts of the Floridan aquifer and lateral encroachment of salt water from the coastal zone. Unfortunately, a basic assumption used in the design of the model is a constant head in the water table aquifer, so the model cannot predict declines in the water table as a function of

pumping from the Floridan aquifer; therefore, very little can be said of the effects on the vegetation and surface-water systems as a result of pumping from the Floridan aquifer.

One aspect that can be evaluated indirectly is the potential for saltwater encroachment in relation to the change in the potentiometric surface. For example, the 1985 potentiometric surface map (Figure 2.5) that was simulated by combining the September 1975 potentiometric surface and the predicted water-level changes under Scenario 2.15 in the year 1985 showed no change in the location of the 20-, 30-, and 40-foot contour lines in the coastal zone. Thus, it may be concluded that the gradient in the potentiometric surface has not changed, nor has the outflow of fresh water to the coast from the Floridan aquifer. This suggests that Scenario 2.15 for 1985 will have no effect on the potential for saltwater encroachment in the coastal zone. However, there are other (beneficial) effects; in southwestern Polk County, water levels will rise 10 feet in certain area, thereby reducing the pumping lift for many wells, which subsequently will result in an economic benefit to the owners of those wells.

On the potentiometric surface map for the year 2000 (Figure 2.6) contours in the coastal zone were more closely spaced than in 1975. More specifically, the 20-foot contour line was still at the same location but the 30-foot contour line had moved somewhat to the western part, followed by the 40-foot contour line. This means that the elevation of the potentiometric surface in the coastal zone will have increased by the year 2000, thereby most likely increasing the outflow of fresh ground water to the Gulf. This will reduce the potential for lateral saltwater encroachment. Apparently, because of Scenario 2.15, more water will be lost to the Gulf in the year 2000 than was lost in 1975.

The sharp rise in water levels in Polk County will provide an economic benefit to owners of wells in those areas because pumping costs will be reduced. No specific information has been gathered or analyzed, but it is entirely possible that the rise in the potentiometric surface in the southwestern part of Polk County will, in certain instances, reinstate free



NOTE: Contours reflect September 1975 surface modified by changes in phosphate industry withdrawal rates only.

Figure 2.4. Simulated Potentiometric Surface, September 1985, under Scenario 2.15

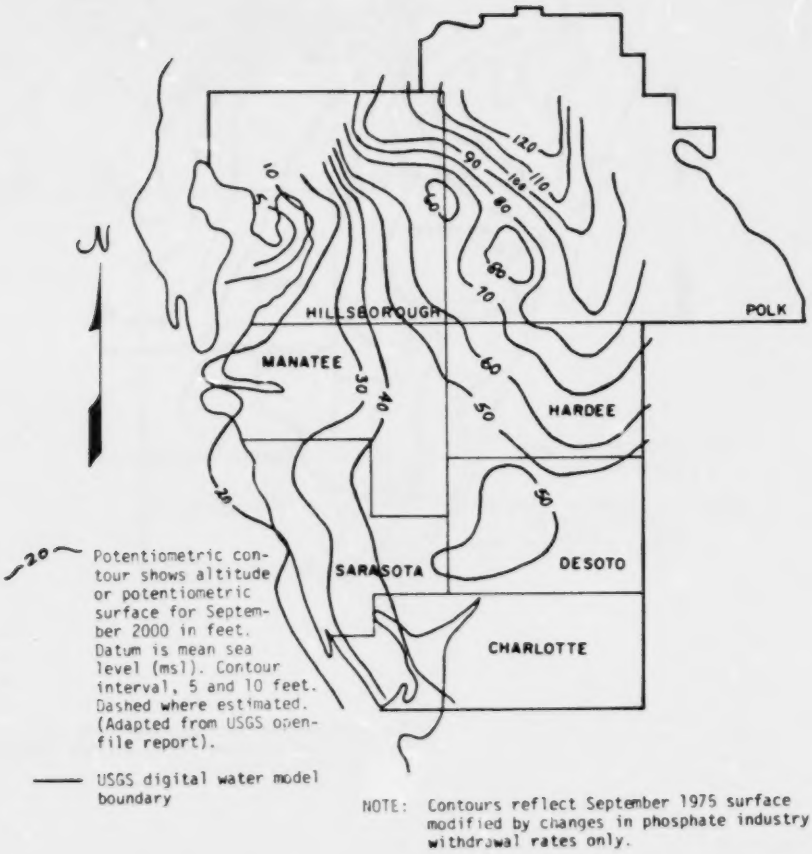


Figure 2.5. Simulated Potentiometric Surface, September 2000, under Scenario 2.15

flow of springs in the area. Although there are no data showing real potentiometric surface contours that would reflect municipal, agricultural, and industrial pumpage, it is clear that completion of existing phosphate mining operations will have a beneficial effect on the water resources in the study area.

2) Water Quality

Secondary effects on water quality were taken to be effects that are potentially present but for which sufficient evidence for concern about them is lacking. These effects are (1) saltwater encroachment due to drawdown of the Floridan aquifer, (2) contamination of the water table and Floridan aquifers by seepage from contaminated ponds causing sinkholes that collapse and allow direct contamination, and (3) radiation concerns because of gyp ponds and reclamation of mining pits.

3) Biological

The phosphate industry's secondary effects on the aquatic biota of the study area involve the effects of waste discharges on receiving water bodies, the potential for spilling hazardous materials at processing plants, and impacts of supporting activities such as electricity generation and transport (shipping). Except for the effects of waste discharges, these secondary effects are considered minor.

Industry discharges of high concentrations of inorganic nutrients (nitrogen and phosphorus), coupled with naturally high ambient concentrations in flowing waters of the study area, result in highly fertile water supporting rich and diverse running-water communities. At the mouths of the Peace and Alafia rivers where the fertile river water enters the estuary are found extremely productive estuarine communities; indeed, the unusually high productivity of both Tampa Bay and Charlotte Harbor can be attributed largely to significant contributions of inorganic nutrients by the major contributing streams (Alafia and Peace, respectively).

Locally, waste discharges of the phosphate industry can be detrimental (e.g., toxic concentrations of ammonia), but such effects are very limited and are outweighed by the beneficial aspects of nutrient enrichment. However, coupled with decreased flow and water motion, this nutrient enrichment can potentially result in severe nuisance hydrophyte problems and degradation of habitat quality.

2. Man-Made Environment

a. Land Use

The reader is asked to refer to the corresponding discussion under primary effects in subsection C.2.a of this section on Scenario 2.15.

b. Archeological, Cultural, Historical, and Recreational

The reader is asked to refer to the corresponding discussion under primary effects in subsection C.2.b of this section.

c. Demography, Economics, and Cultural Resources

Development of Tampa Harbor and development of the phosphate industry are synergistic: development of one presumes development of the other; and conversely, if one is not developed, the other is not likely to be developed. Perhaps not readily apparent to the casual observer, the bulk of employment in the Tampa area is in manufacturing, construction, transportation, and communications - and the harbor (largely supported by phosphate industry shipments) contributes directly or indirectly to all these industries.

Many important industries need the harbor facilities but are not important enough to support them. An example is the Disney World complex near Orlando, one of the major contributors to increased demands for products through Tampa Harbor. New industries such as optical materials and gun manufacturing, construction of prefabricated houses, assembly of foreign trucks imported through the harbor, export of citrus fruit, and processing

of food caught off Florida's coast depend on a viable harbor system. Failure to develop the harbor would cause a decline in these operations.

d. Resource Use

No secondary effects of significance due to phosphate industry activities were identified under this scenario.

SECTION 3
PERMIT EXISTING AND NEW SOURCES

A. DESCRIPTION OF ALTERNATIVE

This scenario examines the central Florida phosphate industry in terms of the conditions of the first scenario but extends its scope to include potential new mining operations and processing plants. In addition to sites that were permitted as of August 1, 1976, potential new mines and plants that were pending review by EPA as of that date are considered. Under the conditions imposed by this scenario, this report does not include facility applications that were made after August 1, 1976; data are not readily available since many of the potential new mines and plants are still in the planning stage. Applicable permits, as in the scenario dealing with issuance of existing sources only, are those relating to the Federal Water Pollution Control Act (PL 92-500), Sections 402 and 404, for existing and new sources, Florida DER and EPA requirements of the Clean Air Act, and other local, state, and federal permits applicable as of August 1, 1976, including reclamation. (See TI 1977b for descriptions of environmental-related laws and regulations pertaining to the phosphate industry.)

Under this scenario, seven new mines and no new chemical processing plants are projected (see Figure 1.1.) It was assumed that all new facilities would be classified as new sources. The potential new sites are distributed throughout Hillsborough, Manatee, Hardee, and DeSoto counties, mostly along the southern portion of the Bone Valley formation, and all except three are outside the existing mining area in Polk County. (The proposed new sites are described and indicated on a map in TI 1977a.)

According to Stowasser (1977), the U.S. Bureau of Mines in 1973 reported 0.943 metric (1.037 billion short) tons of recoverable reserves in the district. Present operations, centered around Mulberry, will inevitably be extended south. In the central Florida mining district, generally high-BPL-grade material with a pebble-to-feed ratio of 1:1 occurs along the upper periphery of the "horseshoe." (The geology and soils of the study area are

described and mapped in TI 1977f: Sections 1, 2, and 3.) Splitting the horseshoe north-south is the Lakeland-Bartow ridge, a zone containing medium- BPL-grade material with a pebble-to-feed ratio that can reach 3:1. The southern part of the deposit, extending into Hardee and Manatee counties, contains matrix of much lower grade: pebble of 55-68 percent BPL and feed heads of 12-20 percent BPL, with a low ratio of pebble-to-feed that, when mined, will send increased percentages of the matrix to flotation mills. Throughout the district, there are variations in matrix thickness and quality, pebble-to-feed ratios, slime settling rates, and chemical qualities of plant water. Such variations have a distinct effect on recovery. The estimated 1.037 billion tons of phosphate rock reserves in the area are also said to contain 150,000 tons of recoverable U_3O_8. The Florida reserves also represent the largest known source of fluorine in the U.S.: they average 3-4 percent fluorine. Both U_3O_8 and fluorine are now being recovered from acid plants and sold as commercial byproducts of phosphate production (Hoppe 1976). (See TI 1977a for a description of resources associated with phosphate in the study area.) One of the new processing plants listed by EPA is to be a uranium recovery operation. One of the new mining operations will combine the reprocessing of old tailings with the mining of virgin land.

Development of Regional Impact (DRI) application information has been utilized wherever possible in preparing projections. For activities that have not yet reached the DRI application phase, estimates have been made using information currently available about permitted mines. From DRI information currently available about predicted production rates and estimated reserves for the new mines, the probable annual mining production rates in the study area have been estimated in accordance with this scenario. These rates are compared with the projections for the scenario of issuing permits to existing sources only and the Florida curves as shown in Figure 1.2.

As described in Section 2 of this volume, groundwater consumption is a matter of great concern to the residents throughout the study area. The addition of the proposed facilities would place an even greater load on

the groundwater supplies of the region. Section 2 discussed the requirement of 1000 gallons of water per ton of phosphate rock produced (mining operations only); based on calculations by TI of a water demand on the Floridan aquifer of 1,500 gallons per ton and the production tonnages of Figure 1.1, water withdrawal by the phosphate mining industry has been projected (Table 1.3). This projection, as in the first scenario, is based on present water consumption and does not take into account any reduction in makeup water that the mining companies may achieve in the future. Again, the primary source of supply is the Floridan aquifer, although two of the future mining operations include plans for obtaining at least portions of their required supply from surface water.

In examining water consumption by the phosphate processing plants, significant problems are encountered. As mentioned in Section 2, not all of the mined rock is processed by local plants; furthermore, the nature of the various chemical processes makes it impractical to estimate water consumption on the basis of production rates for phosphate-related products. Based on the total consumption rate for the 15 existing plants reported by 12 of them, an average of 5,200,000 gallons per day per plant was determined (SWFWMD 1977). Calculations made by TI to include the plants under this scenario forecast a total annual consumption for all existing and proposed plants in the study area of 94,490,000 gallons per day. The processing plants are fixed operations which, in all likelihood, will continue to operate on imported phosphate rock as the central Florida mines are exhausted. Therefore, the water consumption rate should remain approximately at this level, at least until the local mines are depleted; at that time, the cost of imported phosphate rock may cause a reduction of production rates for economic reasons.

Electricity will continue to be the primary source of energy for the phosphate mining and processing industry. Currently, the main supplier is Tampa Electric Company, followed by Florida Power Corporation and then Florida Power & Light Corporation (TEC, FPC, FP&L personal communication 1977); as mining shifts from the existing mines in Polk County southward into the new Hardee and DeSoto sites, however, FP&L will assume larger portions of the load. Existing plants that continue to operate in Polk and

Hillsborough counties as mining activities there decrease will require electric power. In addition, a new uranium recovery plant discussed earlier is to be constructed in Tampa and will be supplied by Tampa Elecric Company. The net result of the conditions set forth by this scenario will be an increase in the amount of power supplied to the study area by FP&L and gradual reduction in the amounts supplied by Tampa Electric and FPC.

Environmental and pollution-control measures are virtually the same as those discussed in the first scenario. Mining operations and transfer of processed materials contribute minor emissions to the atmosphere in the form of fugitive dust. Open burning during land clearing prior to mining releases particulate matter to the atmosphere. Processing plants are monitored for particulates, fluorides, sulfur dioxide, nitrogen oxide, and acid mists, depending on the type of process. Liquid waste discharges must comply with standards set by the National Pollution Discharge Elimination System for existing and new sources as administered by the Environmental Protection Agency. Environmental regulations for the phosphate industry are enforced by the Florida Department of Environmental Regulation from its branch office in Winter Haven, Polk County.

The regulation under which the Florida Department of Natural Resources regulates mine reclamation is Chapter 16 C-16 of the Florida Administrative Code. No reclamation program may include more than 259 hectares (640 acres), which must be contiguous. An EPA report (EPA 1975) discusses radiation levels in reclaimed Florida phosphate land (and this subject is discussed in more detail in TI 1977f: Volume VI, Section 4). Methods of eliminating radiation hazards in structures constructed on these lands are currently under study.

B. MATRIX AND SUPPORTING RATIONALE

1. Natural Environment

a. Atmosphere

From the standpoint of air quality impact, the development of new mining sources (Scenario 2.11') will have the same impact as the alternatives

involving decreased water consumption and limited wetlands activity (Scenarios 2.13 and 2.14). A second alternative to Scenario 2.11 involving only the development of new mines for which DRIs have been written (by 1977) plus the Little Payne mine, will be the same as the 2.11' in 1985 and effectively the same as the 2.15 in 2000. This scenario will not be treated independently.

The development of new mines to replace existing ones as they are depleted will have the effect of maintaining the impact of the industry at a nearly constant level areawide but shifting the local effects due to mining as these operations move around.

The calculated impacts and matrix entries for this scenario are shown below. Variations from 2.15 occur only in the year 2000, for T.D. elements 12 and 13.

	1985		2000	
T.D. Element	Calc.	Matrix	Calc.	Matrix
4	-0.007	0	-0.006	0
12	-0.160	-1	-0.183	-1
13	-0.309	-1	-0.227	-1
17	-0.266	-1	-0.299	-1
18	-0.069	0	-0.067	0
19	-0.010	0	-0.009	0
20	-0.027	0	-0.027	0

b. Land

1) Physical and Chemical

This subsection deals primarily with the effects imparted to the physical environment of the study as forecast under Scenarios 2.11 and 2.11'; the effects imparted to the chemical environment are inherent to industry operations, as discussed in the corresponding subsection in Section 2.

a) Unique Physical Features

The only industry activities that may affect the unique physical features of the area are those that place excessive loads on the natural terrain surface. This may lead to the collapse of any underlying cavity. Such loads are principally in the form of waste-clay slimes and waste gypsum.

The environmental effects under Scenarios 2.11 and 2.11' are rated on the anticipated numerical increase (compared with Scenario 2.15) in the number of mines to be opened. (The rate for gypsum accumulation under Scenarios 2.11 and 2.11' is assumed consistent with that under Scenario 2.15.)

(i) Slime Placement (Line 15)

The effect ratings given for this environmental element under Scenario 2.11 (also indicated in Table 3.1) are -5 for the short term and -1 for the long term, reflecting the scaled differences in the number of mines in operation in 1985 and 2000 compared with the scaled difference in the number anticipated under Scenario 2.11'. A -10 would reflect the anticipated highest difference in number for Scenario 2.11' compared with Scenario 2.15, i.e., the number 15 scaled to equal -10. Scenario 2.11' includes two scavenger mines; Scenario 2.11, one.

Although increased numbers may increase the probability of slime-impoundment collapse, there is no model with which to quantify this potential nor data available to establish the degree of probable alteration of underlying karst features through seepage. Thus, the impact rating entered on the impact assessemtn matrix is "0" for both the short and long terms.

(ii) Waste-Gypsum Placement (Line 22)

Chemical plants are expected to continue operating at approximately the current levels of production, but new gypsum waste stacks probable will be established. Information necessary to quantify the effects and

Table 3.1. Effect of Mining on Unique Physical Features

	Number of Mines Estimated To Be in Operation by Year						Effect Rating*	
Scenario	1977	1980	1985	1990	1995	2000	1985	2000
2.15	18	17	13	11	4	2	0	0
2.11	18	20	20	18	9	4		-1
Δ** to 2.15	0	3	7	7	5	2	-5	
2.11'	18	20	21	26	20	17		-10
Δ** to 2.15	0	3	8	15	15	15	-5	

*Based on numerical differences, with maximum difference (e.g., 15 in year 2000) equated to -10 (Scenario 2.11'-2.15).

**Difference.

Note
Impact ratings equal "0" (see text).

determine the impacts of establishing new gypsum stacks is not available. It is assumed that sufficient knowledge of the underlying strata will be developed under Scenario 2.15, 2.11, or 2.11' before new (proposed) gypsum stacks are established to minimize the potential for their collapse.

b) Soils

The rationale used in assessing effects on area soils having a high potential for agriculture has been discussed in Section 2, subsection B.1.b.

(i) Drilling (Lines 1 and 2) and Land Preparation (Lines 3, 4, and 5)

Compared with Scenario 2.15, Scenario 2.11 is expected to see an increase in these activities. Thus, their effects on soils will be negative. However, because the effects are considered minor and cannot be quantified due to lack of data concerning specific locations of the activities,

"0" impact entries are made on the impact assessment matrix for the two scenarios for both the short and long terms.

(ii) Draglining (Line 6)

In the 7-county study area, there are approximately 453,441 hectares (1.12×10^6 acres) of mapped soil associations that are rated high in potential for agriculture (citrus and truck crops), or approximately 28 percent of the total study area. Draglining under Scenario 2.11 is expected to destroy more than 6,625 hectares (16,370 acres) of these soils over the short term and more than 12,906 hectares (31,890 acres) over the long term. Under Scenario 2.11', these areas approximate 6,625 hectares (16,370 acres) and 15,111 hectares (37,340 acres) respectively.

In the near term under Scenario 2.11, mining activities will affect approximately 1.5 percent of the high-potential soils in the study area; over the long term, about 2.8 percent. Under Scenario 2.11', the respective percentages are 1.5 and 3.3. Based on these small percentages, "0" impact values are entered on the impact assessment matrix. The percentage changes among the various scenarios and the effects ratings developed from these changes appear in Table 3.2.

Table 3.2. Impact of Destruction of High-Potential* Soils by Mining Operations

	Area Destroyed (hectares/acres)		% Change to 2.15		Effect Rating*		Impack Ratings**	
Scenario	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	4,882/12,060	8,534/21,080	0	0	0	0	0	0
2.11	6,627/16,370	12,910/31,890	+35.7	51.3	-5	-7	0	0
2.11'	6,627/16,370	15,117/37,340	+35.7	+77.1	-5	-10	0	0

*Potential for production of citrus and truck crops

**See text.

(iii) Dredging (Line 7)

Soil destruction as a result of dredging operations is included under draglining (Line 6 just discussed). Thus, "0" impact entries are assigned to both the short and long terms.

(iv) Overburden Placement (Line 8)

The effect of placing overburden above grade and covering the soils is considered minor and not quantifiable. Thus, "0" impact entries are made on the matrix comparing Scenarios 2.11 and 2.15.

(v) Product Storage (Line 12)

The creation of product storage piles is anticipated at each of the seven additional washer/beneficiation plants expected to be constructed under Scenario 2.11. This represents an increase of 41 percent (assuming one per plant) over the current number of storage piles. Because the storage area is small relative to mining and study-area acreage and the soils are only disturbed, not destroyed, "0" impact entries are made in the matrix.

(vi) Slime Placement (Line 15)

Slime placement as it affects soils involves only the initial, small slime impoundments that are constructed above grade prior to opening a new mine. It is assumed that these impoundments will be less than 81 hectares (200 acres) for each of the new mines for a total of 557 hectares (1,400 acres) of soils that are permanently covered and removed from other use categories unt ' reclaimed. Because of the small number of acres involved, "0" impact values are entered on the matrix.

(vii) Waste Placement (Line 8)

Placing gypsum wastes above grade and on top of existing soils tends to alter the character of the soils and permanently remove them from other productive use. However, because the area involved is relatively small and no locations relative to prime soil associations are forecast, this loss is assigned "0" on the matrix.

(viii) Construction Activities (Lines 24-27 and 29)

Additional dams and levees (Line 24), transportation lines (Line 25), utility lines (Line 26), washing/beneficiation plants (Line 27), and drainage systems (Line 29) will be constructed under Scenario 2.11. However, these activities involve a relatively small number of acres and disturb soil only locally. Thus, "0" impact values are entered on the matrix.

(ix) Reclamation of Mined Pits (Line 31)

Reclamation of mined pits creates potentially high-productivity soils over about 13 percent of the original, mined area and dedicates the balance to impoundment of clay-slimes and open water. The 13 percent will have a high potential for agriculture because it is likely to possess high nutrient values and good porosity and permeability and lack root-restricting, shallow clay layers. Thus, reclamation of a mined area will tend somewhat to mitigate the negative effects of soil destruction attributed to draglining (Line 6), but only over a portion of the area. The effect rating factor for comparing this action under Scenarios 2.11 and 2.11' with that under Scenario 2.15 becomes +1 (reflecting the 13 percent useful soil figure) for both the short and long terms of each scenario, but the impact values are "0" because of the small number of acres involved relative to the study area.

c) Exposure

How phosphate industry activities expose the geologic section for further detailed study is discussed in subsection B of Section 2.

(i) Prospect Drilling (Line 1)

It is assumed that the additional mines included under Scenario 2.11 have been sufficiently prospected, as evidenced by the DRI studies produced for six of the seven mines, so that minimal additional prospect information will be required. The additional prospect drilling that may be required is not quantifiable but is thought to be small. Thus, "0" impact entries are made on the matrix comparing this scenario with Scenario 2.15.

(ii) Water-Well Drilling (Line 2)

As mining progresses, the drilling of mine-area dewatering connector wells is expected. Although the need for additional data concerning the geologic section in the area cannot be quantified, additional specific information could be derived from these wells. Thus, in the matrix, this impact is assigned a "0."

(iii) Draglining (Dredging) (Lines 6 and 7)

Draglining (dredging) in the seven new mines forecast under Scenario 2.11 will open the section at seven new locations within the study area, representing a 41 percent increase in mine locations. Therefore, a +4 is assigned as an effect rating. The "0" impact rating on the matrix for both the near and short terms signifies an impact but little new knowledge about the geologic section.

(iv) Placement of Tailings and Slimes
(Lines 14 and 15)

Placing tailings and slimes in the mining cuts tends to preclude further detailed study of the exposed section. This is not quantifiable, however, so "0" impact entries are made on the matrix for both the short and long terms.

(v) Mine-Pit Reclamation (Line 31)

Reclamation is the final act that eliminates exposure of the geologic section in the mine pit, but its effect is impossible to quantify and is not considered significant since data concerning the section should already have been collected. Thus, "0" entries are made on the matrix.

d) Topography

Any industry activities that change the original contour of the land (this includes open pit mining, stockpiling product and wastes, and piling of overburden) are considered to have a negative effects.

(i) Draglining (Line 6)

Compared with Scenario 2.15, Scenario 2.11 anticipates the mining of an additional 7,160 hectares (17,600 acres) from 1977 through 1985 and an additional 23,810 hectares (58,500 acres) from 1977 through 2000. Since it is within these additional mined areas that the differential effect between scenarios will be exhibited relative to topographic changes, effects will be consistent with these changes. The effects ratings listed in Table 3.3 were derived from Scenarios 2.11 and 2.11' by setting the maximum percentage change equal to -10 and scaling the other changes on that basis. Impact ratings were developed by comparing acres mined to the study area's total acreage, with impacts being in the negative direction. Under Scenario 2.11', for example, the area to be mined between 1977 and 2000 is 74,343 hectares (183,700 acres), representing only 4.5 percent of the study area's approximately 1,600,000 hectares (4,000,000 acres). On the Scenario 2.11 comparison matrix, therefore, the entries are "0."

(ii) Dredging (Line 7)

The effects of dredging under this scenario are included under draglining (Line 6) just discussed. Thus, impact entries on the matrix are "0" for this activity.

Table 3.3. Forecast of Areas To Be Mined by Scenario

	Thousands of Hectares/Acres							
	Mined		% Change to 2.15		Effect Rating*		Impact Rating*	
Scenario	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	19.9/49.1	32.6/80.6	0	0	0	0	0	0
2.11	27.0/66.7	56.3/139.1	+35.8	+72.6	-3	-6	0	0
2.11'	27.0/66.7	74.4/183.7	+35.8	+127.9	-3	-10	0	0

*Relative to topographic changes imparted by the act of mining.

(iii) Overburden Placement (Line 8)

The placement of overburden from the initial cut of a mining area above grade involves a small area of topographic change. Although the effect is negative, a "0" entry is made to reflect the anticipated magnitude of the impact and the fact that the element was not quantified.

(iv) Product Storage (Line 12)

The creation of seven new phosphate rock storage piles, which are considered to have a negative effect on topography, is anticipated under Scenario 2.11. The effect ratings are "0" because of the small area involved, and impact entries in the matrix are "0."

(v) Tailings Placement (Line 14)

Placing sand tailings in the mine cuts brings the surface nearer to original grade, but the topography of the area after placement of the sand still does not approximate that originally present. Thus, the short-term effect on the comparative matrix is negative, and the same holds for the long term. Since this activity represents no impact, the entries on the matrix are "0."

(vi) Slime Placement (Line 15)

The placement of slime affects the topography of the mined areas since the contour and elevation of the slime impoundments remain considerably different from the original surface. However, since the effect of topographic change has been expressed for the mined area in Line 6, slime placement is given "0" impact entries on the matrix for both the short and the long terms.

(vii) Waste Placement (Line 22)

Gypsum stacks resulting from wet-acid processes dominate waste placement at chemical processing plants. For the short as well as the long term, the effect on topography is negative. Data necessary to quantify this element in terms of potential new stacks and their locations are not available, however, and the involved area is expected to be relatively small. Therefore, the impact is "0" on the matrix.

(viii) Construction of Dams and Levees (Line 24)

Although no quantitative assessment methodology has been developed, this construction activity is considered to have a negative effect on topography. The area involved is small, however, so the impact entries on the matrix are "0" for both the short and long terms.

(ix) Construction of Transportation Lines and Drainage Systems (Lines 25 and 29)

The effects of these construction activities on topography are considered minor in both the short and long terms under this scenario. Thus, impact entries are "0" on the matrix.

(x) Reclamation of Transportation Lines (Line 30)

Reclamation of transportation lines should offset the minor effect of constructing these lines (Line 25).

(xi) Reclamation of Mining Pits (Line 31)

Under presently applied reclamation techniques (which include natural slime pond settling), only approximately 13 percent of the mined area for a given mine is contoured to approximately the original topography of the area. The effect rating on topography in the short-term comparison of scenarios, then, is approximately "0." The effect for the long-term comarison is rated at +1 (the reverse sign of the product of 0.13 and the topography effect rating of -6 entered in Table 3.3). Impacts, however, are "0" because of the small area involved.

(xii) Reclamation of Slime Ponds (Line 32)

Reclamation of naturally dewatered slime ponds leaves a surface that approximates the originally one. Normally, relief is less and elevation is greater. Because of the small number of acres involved relative to the total area of study, "0" impact entries are made on the matrix.

(xiii) Dams and Levees (Line 35)

Reclamation of dams and levees reduces them to grade. The effect of this activity is positive and virtually offsets the effect of their construction (Line 24). No method for quantifying the effect was developed. Because the area involved is small, "0" impact ratings are entered on the matrix.

e) Background Radiation

As previously stated, industry effects on background radiation are based primarily on the resultant disturbance of earth materials and the placement of waste materials and their respective radium-226 concentrations and areal distribution. Impacts developed from these effects must necessarily concern resultant exposure of the general population and the phosphate industry employees. Generally, all radiation exposure is considered harmful, and adverse effects are assumed proportional to dose; in other words, a linear theory rather than a threshold hypothesis is accepted. To

date, no industry activity has been proved to cause a radiation impact on the general population.

As regards phosphate workers, two direct pathways are considered significant: external radiation exposure from gamma radiation (whole-body exposure) and dose received by inhalation (lung exposure) of airborne radionuclides (Windham, Partridge, and Horton 1976). To protect phosphate industry employees as well as the general population from undue exposure by radiation, guidelines in terms of dose rate above existing natural background levels have been published (see TI 1977f: Section 4). Currently, however, no acceptable standards or guidelines are directly applicable to the activities of the phosphate industry in central Florida except the occupational and general public guidelines set forth in the Occupational Safety and Health Standards of the Department of Labor in which it is stated that no individual in a "restricted area" (defined as an area of controlled access to protect against radiation) should receive a whole-body radiation dose equivalent to 5 rems (5,000 millirems) per year or 15 rem (15,000 millirems) per year to the lung. Maximum recommended doses for persons in nonrestricted areas (general population) are given as 0.5 rem (500 millirems) per year to the whole body and 1.5 rems (1,500 millirems) per year to the lung, or 10 percent of the occupational dose.

The Environmental Protection Agency projected the impact on phosphate industry personnel (EPA 1976) and concluded that "all measured direct gamma exposures, even assuming continuous occupancy, are below the current radiation protection guides of 0.5 rem per year for individual members of the general population." This is supported by a University of Florida (1977) study except for some specific areas in the vicinity of rock acidulation tanks and phosphoric acid filters and in piping and tanks; in these areas, however, the industry average time-weighted values are less than 0.5 rem per year.

In terms of lung doses to phosphate industry employees, the EPA's (1976) estimates are well below the current occupational guidance and in most cases below that for the general population. The University of Florida

study reported that all annual cumulative radon progeny values measured fell within the occupational guideline of 4 WLM per year for all locations and that, except for wet-rock loading tunnels, all were less than 10 percent of the guide, even if full occupancy was assumed. In terms of long-lived alpha radioactivity, the University of Florida study concluded that the only areas of interest are dry-rock operations and phosphate fertilizer areas but that these areas, because of plant differences (layouts, quantitites involved, etc.), probably will have to be evaluated for significance on a case-by-case basis.

From the preceding, it is concluded that background radiation changes by chemical processing plant activities are of concern but are of minor significance in the areas studied and that impacts on phosphate workers are reasonably controllable through the application of good housekeeping practices involving common sense. At present, data are insufficient to quantify the effect of radiation levels on ground waters (or the impacts from suspected changes) attributable to seepage from waste-gypsum stacks or cooling-water ponds. The impact discussions that follow are relative to the specific activities of the industry.

(i) Draglining (Line 6)

Background radium-226 radioactivity concentrations are estimated to change locally from approximately 1.5 to 50 picocuries per gram in the mined pit as a result of changing the first surface from original soil to bedclay. It is also estimated under this scenario compared with Scenario 2.15 that such a change will be temporarily (i.e., prior to backfill and reclamation) imparted to an additional 976 hectares (2,411 acres) and an additional 3,243 hectares (8,014 acres) by the year 2000. Under Scenario 2.11', additional areas for the respective years are expected to be 976 hectares (2,411 acres) and 5,716 hectares (14,123 acres). Effects ratings based on these differences for Scenarios 2.11 and 2.11' relative to Scenario 2.15 (Table 3.3) are consistent with those given for topographic disturbances by draglining, i.e., a -3 in the short term and a -6 in the long term for Scenario 2.11 and a -3 and a -10 respectively for Scenario 2.11'. (It

should be noted that areas scheduled for dredging are included in these figures, even though this activity is not expected to appreciably affect background radiation primarily because of the continual water covering of the bedclay and matrix debris using this method. Treating these areas separately would not change effect ratings significantly.)

Annual whole-body dose equivalent gamma radiation computed for a fully employed (40 hours per week, 50 weeks per year) phosphate worker from a background of radium-226 radioactivity concentration of 50 picocuries per gram would be about 185 millirems per year,* well within the guide for the general population. However, for workers involved full-time in draglining in relatively high backgrounds, such exposures would not be anticipated. The University of Florida (1977) study reports an actual measurement/calculation of 30 millirems per year for annual whole-body occupational dose equivalent in a dragline area a level of only 6 percent of guide for the general population. Thus, the impact rating for this activity under this scenario compared with Scenario 2.15 is necessarily "0" for both the short and long terms. The same is true for Scenario 2.11'. Also according to the University of Florida study, the impact of airborne radon-222 progeny expressed as annual cumulative occupational exposure and the impact of long-lived alpha exposures expressed as time-weighted concentrations are commensurately low and insignificant. This evidence indicates that the "0" impact ratings entered on the matrix for Scenario 2.11 are correct.

The ratings do not include consideration that the general population may be secondarily impacted by changes in radionuclide concentrations in ground or surface waters because of this activity; such evidence is lacking.

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*(1.85 milliroentgens per hour per 1 picocurie per gram radium-226) x (2,000 hours)

(ii) Dredging (Line 7)

Dredging affects background radiation levels less significantly than draglining (Line 6). Hence, "0" impact entries are made on the matrix.

(iii) Overburden Placement (Line 8)

The effects that overburden placement has on background radiation are not quantified but are expected to be negligible because of the slight differences between radium-226 radioactivity concentrations for original soil (1.5 picocuries per gram) and overburden (10 picocuries per gram) and the relatively small area occupied by overburden materials outside the mining cuts. For both the short and long terms, then, the comparative matrix receives "0" entries to indicate the absence of impact by this activity.

(iv) Water Extraction and Injection (Lines 9 and 10)

Water extraction and injection are associated with initial dewatering of mine areas using connector wells, and water extraction is also associated with providing makeup water to the second stage of beneficiation. Extraction involves the lower Floridan, the waters of which possess approximately 1-2 picocuries per liter of radium-226 radioactivity concentration. Injection involves gravity flow to the lower Floridan of surface water-table waters having a radium-226 radioactivity concentration of approximately 1 picocurie per liter. Concentration in the upper Floridan waters is approximately 2-4 picocuries per liter.

Because of the essential equality in radium-226 radioactivity concentrations in the water table and the aquifers, no effects from extraction and injection are recognized. Hence, "0" impacts are assigned to the matrix for this scenario.

(v) Product Storage (Line 12)

The radium radioactivity concentration in matrix is between 40 and 60 picocuries per gram. As stated for draglining (Line 6), such a concentration would translate to an annual whole-body occupational gamma exposure of approximately 185 millirems per year, well below the guideline for the general population. Thus, "0" entries are assigned on the matrix.

(vi) Product Drying (Line 13)

While product drying is one of the specific areas of concern relative to industry personnel radiation exposure, gamma whole-body exposures in the dryer areas are below the guideline for the general population, and lung exposure (due to airborne dust particles) are only slightly above the general population guideline but well below the occupational guideline. It is assumed that new dryer facilities developed under this scenario will be no worse than current ones - and probably much better because of improved dust control. Therefore, "0" entries are made on the matrix.

(vii) Tailings Placement (Line 14)

Radium-226 radioactivity concentrations for waste sand tailings and overburden without leach-zone materials are given as approximately 7 and 10 picocuries per gram respectively. When these materials are placed in the mine cuts, they tend to cover exposed bedclay and any matrix materials left in the cut. The radium-226 radioactive concentrations in these latter materials approximate 50 picocuries per gram. Prior to reclamation, approximately 50 percent of the mine cut is expected to be covered with sand tailings and overburden, resulting in effect ratings under this scenario of +1 for the near term (reverse sign of the product 0.5 x -3, the effect of draglining expressed as effects on topography) and +3 for the long term. However because of the size of the area relative to the study areas and the anticipated exposure values for workers and the general population, the impact value is "0." Effect ratings under Scenario 2.11' would be +1 and +5 respectively.

(viii) Slime Placement (Line 15)

Radium-226 radioactive concentrations in clay-slime particulate matter and slime decant water (dissolved fraction) are given as 45 and 2 picocuries per gram respectively. An active slime pond is assumed to be covered completely by decant water, so a net decrease in background radiation is effected by placing slimes in the mine cut. Under this scenario, it is estimated that 50 percent of the mined area will be used for slime retention, thus offsetting the negative effects of mining. Slime placement under Scenario 2.11 has been given effect ratings of +1 and +3 respectively for the near and long terms. Impact values would be "0", again because of the relative size of the area involved and the exposure levels anticipated.

(ix) Production of Fertilizer Products, Animal-Grade Phosphate, and Elemental Phosphorus and Placement of Waste Gypsum (Lines 18-20 and 22)

These activities, which involve the handling of material containing radionuclides, are forecast to continue at essentially the same level for each scenario, at least through the year 2000. The only difference anticipated among scenarios will be the source of rock used to maintain production levels: under Scenario 2.15, phosphate rock will be imported to make up for the unavailability of local rock following depletion in currently permitted mines; Scenarios 2.11 and 2.11' involve only locally produced rock.

Since imported rock is expected to be lower in radionuclide content than local rock, products and wastes produced under Scenario 2.15 should show lower radioactivity concentrations over the long term. According to Habashi (1966), Florida phosphate rock is 4.5 times higher in uranium content (Figure 3.1) than phosphate rock from Morocco, one likely source. Florida rock contains 180 parts per million; Moroccan-rock, 40 parts per million. This suggests that the waste-gypsum stack will receive materials with a lower radium-226 radioactivity concentration if Moroccan rock is used by local chemical processing plants. However, there is no model with which to quantify this, so "0" is assigned in the matrix.

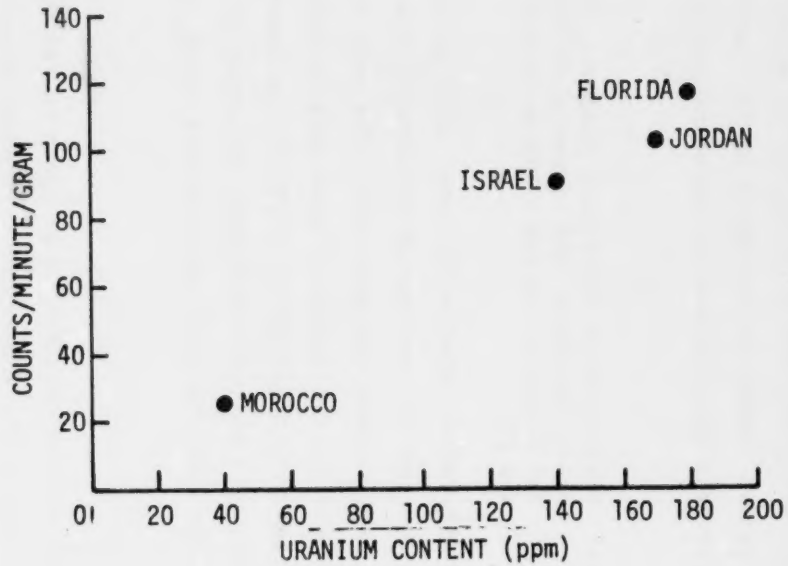


Figure 3.1. Relation between Total Gamma Activity and Uranium Content of Sedimentary Phosphates (Habashi 1966)

Except at a few specific locations, background radiation levels within the processing facilities have been shown to be well within guidelines for the general population (EPA 1976, University of Florida 1977). Also, radiation levels at these locations are not considered hazardous because employees spend minimal time there and company management is aware of the locations.

Because no essential change in throughput or waste accumulation is forecast for the chemical processing plants among the scenarios, "0" impact entries are assigned on the comparative matrix. (The water quality discussion covers the potential impacts on groundwater quality caused by potential seepage of gypsum stacks or cooling-water ponds.)

(x) Construction of Dams, Levees, Transportation Lines, and Drainage Systems (Lines 24, 25, and 29)

In terms of its effect on background radiation, the redistribution of naturally occurring radionuclides because of the construction of dams, levees, transportation lines, and drainage systems will be insignificant. Thus, the impact entries in the matrix are "0."

(xi) Reclamation of Transportation Systems, Dams, Levees (Lines 30 and 35)

The effect of these activities on background radiation is considered minor. Thus, "0" entries are made in the matrix.

(xii) Reclamation of Mining Pits and Slime Ponds (Lines 31 and 32)

Reclaiming a mine segment involves two principal areas: the portion that has received waste sand tailings and overburden land will be reclaimed to lands and lakes, and the portion that will be dedicated to storage of waste clay slimes. It is estimated that these two areas in each mine segment of the additional mines forecast under this scenario will be essentially equal in size and that the ratio of lands to lakes (excluding

the slime ponds) will be approximately 1:3 (specifically, 50 percent slimes, 37 percent water, and 13 percent lands for any given mine). Using these percentages and the radium-226 radioactivity concentrations presented in Table 2.1, it is estimated that a reclaimed area will have an overall (average) radium-226 radioactivity concentration of 23 picocuries per gram, up from the estimated level of about 1.5 picocuries per gram prior to mining. This estimate does not include the normal practice of top-dressing the settled slime pond with surface materials (top soil and overburden) saved for this purpose; that procedure is expected to lower the surface concentration of radium-226 from about 45 picocuries per gram to a value less than 15, depending on the top dressing (University of Florida 1977).

Estimated average values at various stages of mining and reclamation (Figure 3.2) indicate that the highest overall average for a mine segment, approximately 27 picocuries per gram, is at the third stage. This would result in a whole-body gamma radiation dose equivalent of about 438 millirems per year (1.85 microroentgens per hour per picocuries per gram x 8,760 hours per year) for continuous occupancy, which is below the guideline for the general population. Continuous occupancy in the area at this stage is an absurd assumption. It is not possible to estimate radon flux for this hypothetical case because radon flux has been found to be poorly correlated with both gamma radiation level measurements and soil radium-226 concentrations (University of Florida 1977, Florida Department of Health and Rehabilitation Services 1977) and to be highly influenced by soil moisture, clay content, porosity, permeability, etc., all of which may vary locally over a considerable range of values.

It is concluded that mining and reclamation indeed increase background radiation levels. In terms of lowering the background radiation, reclamation of the mined area (including the significant act of top dressing the dewatered slime ponds with appropriate materials) is preferred to simple abandonment. Also reclaiming a portion of the mining pits to water surfaces lowers the overall background radiation level (equivalent to 0.002 picocuries per gram for water compared with 1.5 picocuries per gram for original soil). Thus, reclamation has a direct, positive effect on an estimated 37

DESCRIPTION	UNIT AREA	EST AVG ^{226}R CONCENTRATION
PRIOR TO MINING a. Soil radium-226, 1.5 pCi/g (100%)	a.	1.5 pCi/g (24 mrem/yr)**
IMMEDIATELY AFTER MINING a. 50% active slimes at 0.002 pCi/g equivalent (decant water) b. 50% sand/overburden mix at 9 pCi/g	a. b.	4.5 pCi/g (73 mrem/yr)**
ABANDONED (NATURAL DEWATERING) a. 50% dewatered clay slime surface at 45 pCi/g g. 50% sand/overburden mix at 9 pCi/g	a. b.	27 pCi/g (438 mrem/yr)**
RECLAIMED WITHOUT TOP DRESSING a. 50% dewatered clay slime surface at 45 pCi/g b. 13% sand/overburden mix at 9 pCi/g c. 37% lakes at 0.002 pCi/g equivalent	a. b. c.	24 pCi/g (389 mrem/yr)**
RECLAIMED WITH TOP DRESSING ON CLAY SLIME POND a. 50% top dressed slime at 5.8 pCi/g (one-half top soil at 1.5 pCi/g and one-half overburden at 10 pCi/g) b. 13% sand/overburden at 9 pCi/g c. 37% lakes at 0.002 pCi/g equivalent	a. b. c.	4 pCi/g (65 mrem/yr)**

**Exposure based on continuous occupancy.

Figure 3.2. Estimated Background Surface Radium-226 Radioactivity Concentrations for Hypothetical Mining and Reclamation Sequencing

percent of the original area. The effects values for draglining in terms of background radiation (which related acres mined under the various scenarios) were given as -3 and -6 for this scenario. Reclamation will mitigate these effects up to the percentage of mined land committed to water, i.e., 37 percent. The effects values under this scenario are +1 in the near term and +2 in the long term when compared with Scenario 2.15, but are "0" in both terms and are so entered in the matrix for reclamation of mine pits and slime ponds.

(xiii) Transportation of Mine, Washing/Beneficiation, and Chemical Plant Products (Lines 37, 38, and 40)

Even though there is no model with which to quantify the effects of these activities on background radiation, data show that the effects will be insignificant. The only possible exception would be where product dust is created at transfer points, specifically dry-rock and dry-product transfer points. In all cases, lung doses from airborne particulate matter within the sphere of industry activities are well below the current occupational guidelines for workers and in most cases below the guideline for the general population. In cases where exposures are above the general population guidelines, mitigative measures (e.g., limiting access to the areas or providing protective respiration devices) are anticipated. Because the applicable protective measures are relatively simple, the levels of exposure are generally low, and the production levels of the chemical plants are expected to be constant, these activities are assigned "0" impact values.

f) Noise

Noise generated by activities of the phosphate industry is expected to have virtually non impact on the general population. The reader is asked to refer to the corresponding discussion in Section 2, subsection B.

2) Biological

There will be no change in the direction of the effects of phosphate mining on uplands/wetlands biota. There will, however, be a change in the magnitude of effects on most of the environmental demand elements. Since the relative importance of habitat types to surrounding ecosystems cannot be ignored and quantitative data generally are unavailable, the assessment of magnitude of effects is largely judgmental. Therefore, individual levels within the selected scale of 1 to 10 for beneficial effects and -1 to -10 for adverse effects cannot be distinguished and impacts are considered slight 1, and 2; moderate, 3 and 4; substantial, 5 and 6; severe or highly beneficial, 7 and 8; and worst case or best case, 9 and 10.

a) Impact on Areal Extent

The impact of mining additional freshwater wetlands is considered worst case. If pending permits are granted, an additional 1,943 hectares (4,800 acres) will be mined by 1985, making a total of approximately 4,939 hectares (12,200 acres) from the present to that time (Table 2.2) By 2000, the extent of wetlands mined will total more than 10,850 hectares (26,800 acres), representing 6 percent of the present wetlands extent in the seven counties. Undoubtedly, other development will diminish areawide wetlands extent somewhat, but reference to the future land use map (TI 1977c: Volume III, Plate 8) indicates that greatest depletion will occur in the mining area. Possible effects, as well as the possibility of actual destruction of "undisturbed" wetlands, are discussed in the subsection on water quantity in Section 6.

Since future areawide estimates of uplands habitat types (Table 2.2) are considered more realistic than those of wetlands extent, some consideration can be given to the percent areawide change attributable to mining. All habitat types are projected to decrease in areawide extent by 2000, the greatest (18 percent) occurring in forest extent; 27 percent of the change by 1985 and 69 percent of the change by 2000 will be attributable to mining.

The loss of several hundred acres of mixed and deciduous forest types (Table 2.2) will severely deplete the unknown but undoubtedly limited extent of these important habitats. Only 1,053 hectares (2,600 acres) [approximate] of deciduous forest and 405 areawide hectares (1,000 acres) of mixed forest were noted on the LUDA maps. Although these are considered underestimates, the actual extents would still be quite small compared with estimates of other types. Mining of these types is considered worst-case. The impact of mining deciduous forest would be lessened if there were provisions for natural revegetation of some areas that could eventually support a hardwood association. The severe impact of mining in pine flatwoods is tempered by the projected remaining areawide extent of the type as well as by the fact that unmined, unmanaged rangelands possibly could succeed to pine forest.

Although 85 percent of the projected 7 percent loss of cropland and pasture areal extent by the year 2000 is attributable to mining, the impact is considered negligible: not only are the types extensive in the seven counties, but they are more easily (technologically and economically) replaced than other types. Approximately 62 percent of the areawide loss of rangeland extent by 2000 is attributable to mining. As implied previously (Section 2), the level of impact associated with mining rangeland depends on the extent of dry prairie included. Since dry prairie is not among the cover types listed in phosphate DRIs and other rangelands are extensive in the seven counties, moderate impact is assumed. Although characteristic rangelands (modified pine flatwoods) will not readily reestablish on mined land, reclamation of similar unimproved pastures could ameliorate loss of these types by providing greater opportunities for wildlife than improved pasture provides.

Of the approximately 55,789 hectares (137,800 acres) of uplands/wetlands habitat mined by 2000, as much as 16,599 hectares (41,000 acres) will be permanently displaced by water. As in the case of wetlands, the areawide extent of water projected for 2000 (TI 1977j: Volume X, Table 2.1) is unrealistic. Less than an 810-hectare (2,000-acre) areawide increase, most of it in Polk County (TI 1977c:Volume III, Chapter 4, Table 2.7), is projected.

There is no means of determining in what proportions habitat type areal extents should be downwardly adjusted to account for the underestimate of water extent. Perhaps much of the adjustment would validly fit into the realistic decline of wetlands extent. Because areawide extents of agricultural and rangeland types are quite large, downward adjustment would make little difference in percent change attributable to mining. The conversion of terrestrial habitat to aquatic habitat is a decided impact that cannot readily be discounted on grounds of need for additional aquatic habitat or need for additional recreational areas; it is an unavoidable result of mining.

Reclamation plans suggest that several thousand acres of land and lakes comprising conserved buffer zones and tree plantings around lakes will replace part of the mined landscape. The type of habitat to be conserved varies, but much of it seems to be forested, both wetland and upland. Some small areas of sand pine scrub, for instance, will be conserved because elevations are considered too high and overburden too deep for mining. The extent of conserved land also varies, ranging between approximately 405 and 2,024 hectares (1,000 and 5,000 acres) per site. The conserved land may be (and generally is) disturbed during mining. Some small acreages within the conserved area are categorized as undisturbed. The conserved and undisturbed areas are fragments of original cover types and are less valuable as life-support systems.

A few thousand acres of pine plantation are planned. Plantation, of course, is an agricultural type and considerably less valuable for biota than are natural pine flatwoods. Slash pine apparently is the only species that can be planted with success, not only in the plantations but in other areas where pine planting might occur. Increasing dominance of this species rather than longleaf pine, as occurs naturally, is one of the factors contributing to the declining diversity within forested types in the state (Florida DNR 1975). The greatest reclamation acreage apparently will be improved pasture, which, as indicated earlier (Section 2 and Table 2.3), is only slightly more desirable than cropland as terrestrial habitat. Attempts will be made to establish several hundred acres of marsh.

b) Impact on Habitat Quality

Most of the effects of mining activities on habitat quality as described in Section 2 apparently will have little areawide impact, although some will increase somewhat in magnitude locally. It is assumed that emissions control devices now have been improved as much as possible and that ambient levels of pollutants from processing plants will remain constant along with the rate of processing (see Atmosphere, this section). Continued exposure of certain flora to the contaminants may result in accumulation and possibly alteration in development. As mining moves southward, noise and dust as well as emissions associated with drying will affect local habitat. Except in Hardee County, where phosphate activities are expected to contribute most of the projected increase in emissions, areawide concentrations attributable to mining will be quite small.

The local biota in new mining areas will be affected by cover-type fragmentation, surface- and ground-water changes, and erosion. Although these effects generally are regarded as temporary and not of sufficient magnitude to prevent recovery (DRIs), long-term effects (e.g., reduced carrying capacity) are probable and actually preclude complete recovery. Of prime concern are the effects of alteration of water regime on remaining wetlands. These are not addressed to the extent of similar effects on water bodies; e.g., the distance at which the surface water of nearby lakes will be lowered by mining into the shallow aquifer must be addressed. Perhaps there are long-term effects associated with modifications of remaining wetlands. If modified wetlands are not functioning effectively, the areawide impact of degradation of remaining habitat is greater.

c) Impact on Community Structure

Since phosphate mining is projected to account for more than half of the expected areawide change in areal extent of uplands/wetlands habitat types by 2000, it will account also for most of the change in community structure. The anticipated community structure changes that will accompany land use changes, first in the mining process and subsequently in reclamation, are adverse from an ecological viewpoint (see Section 2). A major

factor in the areawide impact on community structure is the expansion of mining activities within or into the five counties (Polk, Manatee, Hillsborough, Hardee, and DeSoto) that already are most highly modified by urbanization, industrialization, and agriculture (Plate 2 in pocket). Approximately 37 percent (Manatee County) to 55 percent (Hillsborough County) of the present uplands/wetlands habitat in these five counties is agricultural, compared with 12 percent and 15 percent respectively in Charlotte and Sarasota counties (TI 1977c: Chapter 4, Tables 2.2 through 2.8). Rangeland, which generally is an intensely managed habitat also, comprises another approximately 20 percent (Polk County) to 56 percent (Manatee County) of uplands/wetlands habitat in the five counties. Much of the rangeland extent in DeSoto County probably comprises dry prairie. In the other four counties, considerably less than 50 percent of land cover consists of essentially natural systems (wetlands, dry prairie, and forests).

Heaviest mining in pending-permit areas will occur in Hardee County; there, more than 2,713 hectares (6,700 acres) of wetlands, the most diverse habitat, will be destroyed by the year 2000 (Table 3.4) but a minimal amount of forest will be mined. More wetlands than forests will be destroyed also in Hillsborough County and in the newly mined counties of DeSoto and Manatee. Of the lesser mined counties, Hillsborough will have the greatest loss of forest: nearly 1,619 hectares (4,000 acres) will be destroyed by the year 2000. In already heavily mined Polk County, an additional 5,182 hectares (12,800 acres) of forest and 3,077 hectares (7,600 acres) of wetlands will be destroyed.

Projected mining, which is depicted as Scenario 2.11' in Figure 10, will destroy greater amounts of wetlands than forest in all five counties. The loss of significant amounts of wetlands likely will cause much of the expected decline in diversity in the new mining areas, but some of the expected decline will be associated with loss of natural uplands habitat, particularly sand pine scrub and sandhills. More than 18,340 hectares (45,300 acres), or approximately one-third, of the uplands/wetlands habitat to be mined by 2000 in permitted and pending-permit areas (Table 2.2) comprise essentially natural systems.

Table 3. 4. Approximate Acreages of Terrestrial Habitat Types To Be Mined by 1985 and by 2000 per County per Scenerio

	Area (Hectares/Acres)									
	DeSoto		Hardee		Hillsborough		Manatee		Polk	
Habitat Types	1985	2000	1985	2000	1985	2000	1985	2000	1985	2000
2.15										
Cropland and pasture	-	-	-	-	984	3,238	-	-	2,823	5,413
					2,432	8,000			6,976	13,376
Orchards, groves, etc.	-	-	-	-	130	907	-	-	-	-
					320	2,240				
Rangeland	-	-	-	-	130	544	-	-	3,704	6,138
					320	1,344			9,152	15,168
Forest (primarily evergreen)	-	-	-	-	699	984	-	-	2,357	3,859
					1,728	2,432			5,824	9,536
Uplands (total)	-	-	-	-	1,943	5,672	-	-	8,884	15,411
					4,800	14,016			21,952	38,080
Wetlands	-	-	-	78	1,425	2,072	-	-	1,580	2,979
				192	3,520	5,120			3,904	7,360
Total	-	-	-	78	3,367	7,744	-	-	10,464	18,390
				192	8,320	19,136			25,856	45.440
2.11										
Cropland and pasture	544	570	,492	2,305	1,425	5,154	1,502	3,315	3,212	6,501
	1,344	1,408	1,216	5,696	3,520	12,736	3,712	8,192	7,936	16,064
Orchards, groves, etc.	26	26	-	52	-	906	-	363	-	-
	64	64		128		2,240		896		
Rangeland	699	1,736	673	5,886	1,140	2,590	207	1,709	3,937	6,372
	1,728	4,288	1,664	14,544	2,816	6,400	512	4,224	9,728	15,744
Forest (primarily evergreen)	-	78	78	207	725	1,606	337	363	2,901	5,206
		192	192	512	1,792	3,968	832	896	7,168	12,864
Uplands (total)	1,269	2,409	1,243	8,418	3,419	10,257	2,046	5,750	10,050	18,079
	3,136	5,952	3,072	20,800	8,448	25,344	5,056	14,208	24,832	44,672
Wetlands	440	622	52	2,745	1,658	2,979	1,217	1,425	26	3,112
	1,088	1,536	128	6,784	4,096	7,360	3,008	3,520	64	7,680
Total	1,709	3,030	1,295	11,163	5,077	13,235	3,264	7,175	10,075	21,187
	4,224	7,488	3,200	27,584	12,544	32,704	8,064	17,728	24,896	52,352

The impact of a decline in landscape-pattern diversity is important not only on an ecological basis but from social and economic viewpoints (see the land use discussion that follows). Preservation of rare or valuable ecosystems is becoming a major concern in land use planning. Additionally, the holistic concept of regional carrying capacity, which considers the ability of the regional environment to sustain particular levels of activity, is being advanced (Bishop et al 1974). A certain balance between managed systems that require expenditure of energy and natural systems that do not is necessary if quality regional environment is to be maintained. Since further displacement of natural systems in an area of mostly managed systems could stress the existing carrying capacity, the desired level of environmental quality should be considered when regulations relative to future land use (reclamation) are proposed. Since productivity and the capacity to assimilate residuals and wastes are the limiting factors of the

natural environment on the human sector (Bishop et al 1974), wetlands must indeed be Florida's most valuable natural systems from the standpoint of benefit to society (see Section 2).

d) Impact on Important Species

(i) Threatened and Endangered

Pine flatwoods and particularly mixed forest are important to most of the 12 threatened and endangered species that are likely to be affected by mining. Of the species closely or entirely associated with sandhills and sand pine scrub (Table 2.6), the Florida mouse is expected to be the most severely affected. Apparently, the areawide distribution of this species is limited to the northern half except for an isolated population in Sarasota County. Locally, it is generally rare. The reported abundance of the species on one mining site (W.R. Grace & Co. 1975), however, is comparatively high (20 individuals per 100 trap nights), indicating the probable elimination of a significant number of individuals of this endemic species.

Although unreported, isolated populations of the endemic, secretive, short-tailed snake could well exist in the remaining patches of sandhills and sand pine scrub in the mining areas of Hillsborough and Polk counties. Also in the same habitat but at higher elevations in southwestern Polk County, there could be isolated populations of the endemic, equally secretive, sand skink, which is closely associated with the Lake Wales Ridge. Although the numbers of these species eliminated by mining may not be as great as that of the Florida mouse, the effects on their areawide distributions could be equivalent or greater, particularly in the case of the short-tailed snake, which is believed to be the rarest of the three species in the study area.

The distribution of the Florida Scrub Jay, the other species essentially limited to scrub habitat, is areawide, with isolated occurrences along the coast where backdunes vegetation is often similar to that of sand

pine scrub and, more rarely, inland in the southern part. Despite the area-wide distribution, mining's effects on the remaining population are considered important because this endemic subspecies is well isolated from the other North American scrub jay, which occurs in southwestern U.S. Potential impacts on these four unique vertebrates are worst-case, as is the decline of their already severely limited habitats. Creating similar habitats for the species would require conservation or restructuring soils and restoring appropriate elevations, all of which may be considerably less practical than conserving the small amounts of sandhills and sand pine scrub presently available. Allowing periodic fire is essential for conservation of these habitat (TI 1977f: Volume VI, Section 5).

Impacts on the Florida gopher frog and the Southeastern American Kestrel could be severe. The Florida gopher frog, which occurs sporadically throughout most of the study area in several habitats, apparently is rare, although its secretive habits make estimates difficult. The decline in Florida populations of the subspecies apparently is linked to loss of favored habitat, and further destruction of favored habitat, sandhills and sand pine scrub, could eliminate a significant number of this rather widespread subspecies. In the case of the Southeastern American Kestrel, regional extirpation is feared (Layne et al 1977) if mining substantially reduces the concentrations of residents in eastern Manatee and western Hardee counties.

Potential impacts on the gopher tortoise, eastern indigo snake, Sherman's fox squirrel, Wood Stork, Florida Sandhill Crane, and Southern Bald Eagle are moderate to substantial. These species or subspecies are widespread in the seven counties and are equally or more abundant along the coast or in other areas not affected by mining. Of particular concern in the event of future phosphate scavenging operations, however, is the concentration of nests of the Southern Bald Eagle in old mining areas. The eagle, as well as many other important species occupying abandoned mining areas, could be seriously affected if extensive disturbances of revegetated mined land were to occur.

(ii) Ecologically Significant

The areawide impact on ecologically significant species in general is considered moderate over the short term and substantial over the long term as greater amounts of forests and wetlands particularly are mined. Permanent population declines among most of the affected species are expected. Many of them, however, are attracted to shallow mining pits and vegetated slime ponds. Maintaining suitable impoundments for these species would be one of the more feasible aspects of a reclamation plan oriented toward alleviating the effects on wildlife.

(iii) Commercial and Recreational

As previously implied (Section 2), the areawide impact on the hunting and trapping potential of commercial and recreational species is considered minimal, as is the impact of increased abundances of nuisance and pest species. Assessment associated with effects on commercial and recreational species is based on the relatively small revenue derived from hides of wild animals and the commitment of the Florida Game and Fresh Water Fish Commission to maintain an abundance of game. If the cost of maintaining huntable populations in the area is unduly increased because of extensive changes in land use, then the impact of mining, which is responsible for the greatest change, will be greater. Similarly, there may be undue costs associated with controlling nuisance and pest species, particularly in maintaining an environment with tolerable levels of chemical contaminants. The impact of increased abundance of nuisance and pest species on other biota is considered in the expected changes in community structure.

c. Water

1) Water Quantity

The methodology used to assess the effects of future pumpage by the phosphate industry in relation to the scenario conditions as defined under subsection A was based primarily on the use of the USGS digital water model, which is detailed in Section 2, subsection B.1.c. The data output from this model formed the basis for comparing Scenario 2.11 with Scenario

2.15. In accordance with the data base, the following assumptions were established:

(1) No true impacts as a direct result of pumpage from the Floridan aquifer can be established since the results of the USGS water model reflect only the changes in phosphate industry water withdrawal rates. No changes from 1975 withdrawal rates of municipality, agricultural or other industries were used in the model runs. The temporal and spatial stresses on the Floridan aquifer resulting directly from phosphate industry activities can be determined within the constraints of the model, but the evaluation should not be construed as absolute. Though refinements are needed the model does represent the best tool available for analysis impacts of alternative water use strategies.

(2) Potentiometric fluctuations in Polk County were not considered.

(3) Drawdowns will be used as the basis for scenario comparison. It is extremely important that the reader realize that the drawdown evaluation represents only a technique for scenario comparison; the drawdowns represented are insignificant relative to impact on the Floridan aquifer.

(4) The average drawdowns used for this evaluation were as follows:

	Avg Drawdown in Feet above MSL	
Scenario	1985	2000
2.15	8	0
2.11	8	8

(5) To determine a negative effect a 30-foot drawdown was assumed to represent a -10; while 0 feet, no effect. From this scale, a 5 foot drawdown was determined to be -3.

(6) From assumption 4, it is clear that there is basis for comparison in the year 2000.

(7) Since there is the possibility of separating the effects of mines and chemical plants, each activity is treated as having the effect.

2) Water Quality

The areas affected under Scenario 2.11 for the short term (1977-85) are all of the areas of the "Without Action" alternative plus Troublesome Creek (P.9), Horse Creek (HC.1, HC.3), Big Slough (BS.1), the Myakka (MY.1) and Manatee (M.1) rivers, and the south fork of the Little Manatee River (LM.2). Over the long-term (1985-2000), there will be some additional activity along the Peace River (P.7), the south prong of the Alafia (P.8), and the east fork of the Manatee river (M.1). All of these segments are Class-III waters except BS.1, which is Class I.

The technological demand elements that will have a significantly different affect on water quality from the "Without Action" alternative are clearing and burning, slime placement, water use/recycle from beneficiation, and construction of dams and levees.

a) Clearing and Burning (Lines 4 and 5)

Over the short term, 7,126 hectares (17,600 acres) more than under the "Without Action" alternative will be mined in the study area; 3,765 hectares (9,300 acres) will be in areas not previously exposed to mining. Runoff from these additional cleared acres, which may increase sedimentation and turbidity, potentially will affect Class-I waters (the upper and lower Myakka lakes, Lake Manatee, and Big Slough) and may carry increased nutrient loading and organic detritus into stream segments, including the Lake Manatee and the upper and lower Myakka lakes, which would receive additional enrichment that could lead to eutrophication problems. The effects of clearing and burning (considered as a difference from the "Without Action" alternative on a scale of barely significant [$\pm$1], moderate [$\pm$5], highly significant [$\pm$10]) are considered to be -5, as is the long-term difference in hectares (acres) mined: 23,846 (58,900).

b) Slime Placement (Line 15)

As discussed under the "Without Action" alternative (Section 2, subsection B), slime placement is a potential source of large contamination

problems, especially to surface waters, wherever the slime ponds exist. Since slime-pond breaks under this scenario might cause the loading of slimes to Class-I waters, the effect on surface water quality is considered highly significant (-7).

c) Washing/Beneficiation Water Use/Recycle

All of the additional mining facilities considered under this Scenario 2.11 are new sources and therefore must comply with New Source Performance Standards, which prohibit discharges to surface waters. Thus, there would be no change in surface water quality pollutional load from the "Without Action" alternative but there could be localized degradation effects on the quality of Floridan aquifer water. The effect is considered barely significant (-1).

d) Construction of Dams and Levees

It is estimated that over the short term and long term an additional 2,713 hectares (6,700 acres) and 8,785 hectares (21,700 acres) respectively will be reclaimed to surface water impoundments under Scenario 2.11. However, the additional 21,700 acres on which dams and levees will be constructed is considered to be barely significant (-1) from the standpoint of the construction contaminating surface water.

3) Biological

a) Areas Affected by Phosphate Industry Activities

During the short term (1977-85), aquatic habitats likely to be affected by phosphate mining activities under Scenario 2.11 include Little Payne, Troublesome, and Brushy Creeks in Hardee County; Harse Creek and Brandy Branch in DeSoto County; Big Slough and Wingate Creek in Manatee County; and several small drainage courses in upper portions of the Manatee and Little Manatee rivers. During the long-term (1985-2000), mining activities will continue to expand in the same areas, but some additional activity will occur along the Peace River immediately north of the confluence

with Little Payne Creek, in the drainage of the south prong of the Alafia River, and in the east fork of the Manatee River.

b) Threatened and Endangered Species

Although different localities will be affected, the primary effects of industry activities on threatened and endangered aquatic species will be essentially the same as those described for Scenario 2.15, with one exception: since considerably less mining activity will occur in the Alafia River basin under 2.11 than under 2.15, there will be virtually no potential for adverse effects of the industry on the Suwanee cooter.

The potential effects of slime spills in areas mined under Scenario 2.11 will be very similar to those described for 2.15 for the American alligator but will be less than those of 2.15 for the Suwanee cooter since there will be less mining activity in the Alafia River basin. On the other hand, the potential effects of slime spills on the manatee are heightened since mining activities under 2.11 occur much closer to the lower Peace River habitat of the endangered mammal.

c) Species of Commercial and/or Recreational Importance

Primary effects of phosphate industry activities on commercial and recreational species will be very similar to those described for Scenario 2.15, although locations of impacts will vary. The impoundment of large quantities of slime in the mining area along Horse Creek in eastern DeSoto County represents the most potentially severe threat to sport and commercial species of the study area posed by the industry. A significant spill into the Horse Creek drainage would seriously affect the lower Peace River and the Peace River estuary, impacting such important species as largemouth bass, channel catfish, bream, snook, and mullet; a good blue crab fishery; and important forage fishes.

d) Nuisance and Pest Species

Effects of industry activities under Scenario 2.11 wil be very similar to those described for 2.15, although locations of effects will vary. Additionally, significant increases in nutrient loading (nitrogen and phosphorus) in streams that experience very low (or zero) flow during portions of the year (Horse Creek, Big Slough, upper Myakka River) are expected to exacerbate nuisance hydrophyte and filamentous algae in those streams.

e) Standing-Water Communities

The effects of industry activities on smaller standing-water communities of the study area under Scenario 2.11 will be similar to those described for 2.15, although locations of effects will vary. However, unlike those in Scenario 2.15, the 2.11 projected activities can potentially affect several major standing water bodies in the study area (i.e., the upper and lower Myakka lakes and Lake Manatee). Since those lakes are located on drainage courses, the effects of activities in upper portions of the watershed can directly impact the lake ecosystems. Although short-term effects will be minimal, phosphate industry activity in the long-term will accelerate the aging of the lakes by increasing siltation and eutrophication (nutrient enrichment) and exacerbate nuisance hydrophyte and algae. A significant slime spill entering any of the lakes will have devastating results on the aquatic ecosystem. Recovery of the lake ecosystem will require considerably more time than that necessary for stream recovery and will never be complete. Such an accident represents an irreversible effect in that the useful life of the lake will have been considerably shortened.

Mining and reclamation activities under Scenario 2.11 will create approximately 8,785 hectares (21,700 acres) of new standing-water habitat by the year 2000. This represents a substantial potential for sport and commercial fisheries and wildlife utilization and proper reclamation and management plans.

f) Running-Water Communities

Industry activities will affect running-water communities in the study area under Scenario 2.11 essentially as described for 2.15, but more streams in the southern portion of the study area will be affected under 2.11. An important factor to be considered under 2.11 is that the impoundment of water through total projected mining and reclamation in the Peace River basin (2.11 + 2.15 through 2000) will result in evaporation losses estimated to be equivalent to a reduction of more than 35 cubic feet per second in streamflow in the lower Peace River. Although this is a relatively small proportion of mean discharge for the river (1,195 cubic feet per second), the effects of this reduction during low flow periods could be substantial. The total effect of projected alterations in the flow regimes of streams under Scenario 2.11 will be relatively minor; when considered in combination with industry activities described for Scenario 2.15, however, the magnitude of flow alteration will be sufficient to cause some noticeable community shifts to more undesirable forms in the major streams (particularly the lower portions of the Peace and Alafia rivers).

g) Bay and Estuarine Communities

The effects of phosphate industry activities on bay and estuarine communities will be essentially the same as those described for Scenario 2.15 (principally, long-term effects on freshwater discharge patterns of major contributing streams). However, since some of the 2.11 activity will occur in closer proximity to an important estuarine community (Charlotte Harbor), the likelihood of direct effects becomes greater.

Additional nutrient loading (nitrogen and phosphorus) in the Peace River estuary (via Horse Creek) will stimulate the productivity of the river estuary. Although the lower Peace River probably will receive some turbidity because of mining activities in the Horse Creek basin, effects are not likely to be experienced except in the lower Peace River and the northernmost portion of the Peace River estuary - and they will be minimal.

The accumulation of impounded slime due to industry activities in the Big Slough and Horse Creek drainages will represent a potential hazard of considerable significance to the Charlotte Harbor estuarine ecosystem.

Substantial long-term alterations of the freshwater discharge of Peace River (2.15 plus 2.11 activities) into Charlotte Harbor will change salinity patterns in the Peace River estuary. The increases, although subtle, are expected to change the distributions of major plant communities (mangrove, emergent and submerged macrophytes), and this, in turn, will change associated benthic and fish communities. The summary result of these alterations will be a small expansion of estuarine habitat into the lower Peace River and equivalent loss of freshwater habitat.

2. Man-Made Environment

a. Land Use

1) Land Tenure, Public and Private

The working definition of land tenure in regard to the "Permit Existing and New Sources" scenario (2.11) is identical to that for the "without action" alternative (2.15). (The reader is referred to Section 2, subsection C.2.a of this volume.) The 2.11 alternative exceeds Scenario 2.15 in number of acres mined (Table 2.14). However, land ownership patterns probably will not change since very little land will be acquired by the phosphate industry in addition to present holdings.

This minimal change in land tenure will result in no change in the effects as listed on the 2.15 matrix and will result in few impacts.

2) Community and Regional Plans

As in the case of land tenure, the conditions of Scenario 2.11 will not alter the anticipated effects outlined in Secion 2, subsection C.2.a (the "Without Action" alternative) of this volume. There are few negative impacts except in the "problem" pollution areas, product drying

and waste placement. It is difficult to quantify these negative impacts, but planning at all levels addresses the problems of air and water pollution.

Reclamation, by converting potentially vacant land to some type of more traditionally productive use, produces positive impacts on regional and community plans. Again, quantification is difficult, but a small positive impact is deemed appropriate since planning, especially at the county level, specifies the implementation of reclamation by mining companies.

3) Land Use

Additional acres mined under Scenario 2.11 will affect the following land uses through displacement: forests, agriculture, and open space. The effects are summarized in Table 3.5.

Table 3.5. Displacement Acreages, 1985 and 2000 (Scenario 2.11)

	Land-Use Category (keyed to matrix elements)	Area (Hectares/Acres) Four River Basins	1975 (unadjusted)	Acres Mined According to Map	Difference	% Change Areawide Due to Mining
1985	Forests	55,117/136,138	69,677/172,101	3,990/9,856	14,560/35,963	27
	Agriculture	42,601/1,052,246	456,908/1,128,563	7,333/18,112	30,825/76,137	24
	Open Space (includes USGS categories "rangeland" and "other barrenland")	471,763/1,165,255	492,649/1,216,843	6,641/16,403	20,886/51,588	32
2000	Forests	58,808/145,255	69,677/172,101	7,462/18,432	10,869/26,846	69
	Agriculture	426,947/1,054,560	456,908/1,128,563	19,220/47,474	29,961/74,003	64
	Open Space (includes USGS categories "rangeland" and "other barrenland")	469,540/1,159,763	492,649/1,216,843	18,267/45,120	23,109/57,080	79

Providing a basis for comparing the effects of the "Without Action" alternative and the "Permit Existing and New Sources" alternative is the difference in percentage of areawide change due to mining (Table 3.6). Nevertheless, assignment of impact is largely judgmental due to the fact that loss of acres in a land use category does not necessarily imply a negative impact. Some consideration must be given to the economic and ecological values of various land uses.

Table 3.6. Percentage of Areawide Land Use Change due to Mining (Comparison of 2.15 and 2.11)

	Percentage			
	1985		2000	
Land Use Category	2.15	2.11	2.15	2.11
Forests	23	27	52	69
Agriculture	15	24	38	64
Open space	44	32	62	79

Since the impacts are largely judgmental, narrative must supplement the matrix designations for each environmental element column (a land use category). The following numerical values and verbal equivalents were assigned to the effects matrix on a scale of ± 10:

1-2	Slight
3-4	Moderate
5-6	Substantial
7-8	Severe or highly beneficial
9-10	Worst case or best case

Specific weighting factors were not applied to the land use environmental elements because there are no accepted quantitative values assigned to different land uses, especially since the "desirability," or "preference" for one land use over another is frequently subjective. Many demands on different lands are related to recreation, aesthetics, or environmental quality; the demands for these uses cannot always be met through typical market process. The characteristics of the resource user group (e.g., those who seek recreation, aesthetics, or improved environments) often differ from those of the resource owners (e.g., farmers, real estate speculators, mining companies), and conflicts over the relative values placed on land arise from this separation (Lasey 1977).

Residential, commercial, and industrial lands are seldom displaced by mining because of their high values per acre. As stated in the discussion of land use under the "Without Action" alternative, the presence of mining will stimulate economic growth and actually cause areal expansion of these land uses (Table 3.7).

Table 3.7. Projections for Residential, Commercial, and Industrial Land Use in 7-County Study Area*

Category	Area (Hectares/Acres)		
	1975	1985	2000
Residential	79,376/196,059	101,900/251,693	119,338/294,764
Commercial	8,742/ 21,593	10,148/ 25,066	10,969/ 27,094
Industrial	10,362/ 25,595	16,336/ 40,349	15,567/ 38,451

*U.S. Corps of Engineers (1976).

Mining's impacts on residential, commercial, and industrial land use will be in the same direction as the effects listed on the 2.15 matrix. For example, construction activities that stimulate growth will have positive impacts either directly or indirectly in the abovementioned land use categories.

Negative impacts will be minimal and will be primarily associated with residential use because of its relative sensitivity to any nearby mining activities. One impact will involve a potentially polluting industry activity, product drying.

Impacts on the areal extent of mined lands are directly related to the economic "health" of the industry. In Scenario 2.11, for example, increases in actual number of acres mined are projected to be 39 percent by 1985 and 60 percent by 2000. The increase will result in a positive impact, for example, in the clearing and draglining phases of mining.

Assigning impact values to the forest, agricultural, and open space land use categories involves a definite judgmental factor beyond the displacement of acres by mining and the overall acreage changes between Scenarios 2.15 and 2.11. Numerous factors contribute to the ultimate distribution of these land uses, including both the actual mining and reclamation processes described in the following paragraphs. Impact assessment for land use categories is particularly enigmatic because of "interpretation" can be

by either economic or ecological criteria. Considering both the economic value of a particular land use and its ecological importance creates a situation in which the analyst must weigh these relative values in an attempt to determine overall impact. However, the ecological and economic aspects are not mutually exclusive: types of land use that support unique and/or endangered habitats are valuable, for example, from the standpoint of recreational potential or scientific study. Although not a widely held principle of land use at present, there is increasing acknowledgment by land use planners that there is the need to recognize and assign economic values to land use and land cover types that support unique and/or endangered habitats (Reilly 1973).

Mining and reclamation have negative impacts on forests. Mining will contribute 27 percent of the short-term areawide changes in forest acreage under the "Permit Existing and New Sources" alternative, compared with a 23 percent change under the conditions of the "Without Action" alternative. Over the long term, the difference will be more pronounced: 69 percent under Scenario 2.11; 52 percent under Scenario 2.15 (Table 3.6). The negative impact (-4, -8) will be largely the result of destroying habitat and reducing the diversity of land use. Habitat has economic impacts in terms of land-based recreation (hunting). Reducing the diversity of land use disrupts balance of land use - a condition that is environmentally undesirable. Reclamation causes few positive impacts, and even these are minimal (+1, +2), since reforestation is not a major component effort. (See the terrestrial biota discussion in this subsection; also, the economic impacts of mining on forest and agricultural land are covered in the subsection on demography and economics, and the value of forests as an extractive industry product is detailed in the "resource use" subsection [d].)

Mining has a negative effect on agriculture (as noted for Scenarios 2.15 in Section 2, subsection B.2.a). The impact (-2, -4) is less when compared with the 23 percent change under the "Without Action" alternative. Over the long term, the difference is more pronounced: 69 percent under 2.11; 52 percent under 2.15 (Table 3.6).

Mining negatively affects agriculture (as noted for Scenarios 2.15 in Section 2, subsection C.2.a). The impact (-2, -4) is less than that for forests, although there is a greater percentage of areawide change in agricultural land use (2.15 versus 2.11) than in forests (Table 3.6). A lesser impact is assigned due to the questionable desirability of agricultural land, as a land use type in the study area.

Specifically, mining's destruction of forests, unimproved pasture, and wetlands and replacing them with citrus groves and improved pasture through reclamation irrevocably destroys wildlife habitat and diminishes the diversity of land use. The latter can cause an overall decline in the quality of land use from the standpoint of a balance of areal extent among the major land uses. In addition, the establishment of additional citrus groves or unimproved pasture is unwise from the standpoint of water conservation; agriculture uses more ground water than any other land use type (TI 1977e: Chapter 1). Actually, reclamation of the majority of mined lands to an agricultural land use (improved pasture, citrus groves) creates a negative impact in itself but is an attractive alternative for the phosphate industry; land ownership remains with the industry, since agricultural land is usually leased to a farmer or rancher, and the option to remine remains open if remining becomes profitable at a later date.

Mining poses no short-term impact on open space (Table 3.6); in fact, over the short term, other land uses (e.g., expanding urban areas) impact open space more. The long-term substantial negative impact (-5) given was based on the destruction of an important land cover type. Again, the decease of land use diversity was a major factor in this negative impact assignment.

b. Archeological, Cultural, Historical, and Recreational

1) Archeological, Cultural, and Historical Sites

More archeological and historical sites will be disturbed under the conditions of the "Permit Existing and New Sources" scenario than under

the "Without Action" scenario. As was indicated in Table 2.18 listing numbers of sites disturbed by scenario, five more sites (i.e., 11 rather than six) would be disturbed by 1985 and 18 more (28 versus 10) by the year 2000.

The negative impact of exploration and mining technological demand elements, especially draglining, will be catastrophic (-10, -10). Sites that are irreplacable would be destroyed (Section 2, subsection B.2.b elaborates). Lesser impacts would occur as a result of clearing (-1, -3) and burning (-1, -1) because of the possibility of destroying vegetation that is a part of the natural environment of a cultural site.

2) Recreational

a) Water Based

The most notable negative impacts of the "Permit Existing and New Sources" scenario on water-based recreation would be th increase in potential for water pollution. The most obvious source is the technological demand element, waste placement, which offers the potential for wastewater spills. The potential impact has been judged to be moderate (-3, -3) - but locally, a spill would be catastrophic.

Reclamation of mining pits would produce a positive impact (+1, +3) by increasing the hunting potential for most waterfowl through lake and pond habitat acreage increases.

b) Land-Based

Land clearing and associated habitat destruction will decrease the quality of land-based recreation, resulting in a moderate to substantial negative impact (-3, -5). The decrease in habitat types is described in the terrestrial biota discussion in this section.

Although reclamtion will create some recreational areas having land-oriented activities, the majority of the recreational activities will be water-based. The majority of slime pond and mining pits are reclaimed to improved pasture and therefore are not conducive to land-based reclamation. There will be only a slight (+1, +1) positive impact.

c. Demography, Economics, and Cultural Resources

The reader is referred to the discussion in Section 2, subsection B.2.c.

d. Resource Use

The area's mineral resources have been previously categorized (Section 2, subsection B) into primary, secondary, and tertiary for the purposes of effects assessment and impact determination. In judging the impacts of mineral resource depletion, effect ratings are first determined and then modified on the basis of the category. Specifically, in determining the impact of depleting a primary resource, the effects rating for that resource is factored by unity (1); in determining the impact of depleting a secondary resource, the effects rating is factored by 0.5; and in determining the impact of depleting a tertiary resource, the effects rating is factored by 0. Effects determinations are based on depletion estimates for each identified mineral resource of significance in the area and are discussed in the following paragraphs.

1) Clearing (Line 4)

The loss of timber, a secondary resource, results from the clearing of forest lands in preparation for mining. Under Scenario 2.11, estimated total forest land clearing will involve more than 3,966 hectares (9,800 acres) from 1977 through 1985 and more than 7,366 hectares (18,200 acres) from 1977 through 2000, an increase over the "Without Action" alternative of 27 and 53 percent respectively. No additional mining over Scenario 2.11 is forecast for Scenario 2.11' during 1977-85, but an increase of 67 percent over the "Without Action" alternative is forecast for the period 1977-2000.

Impact ratings for the loss of timber resources under the various scenarios are based on comparing estimated forest lands (LUDA Category I) lost to mining during 1977-85 and 1977-2000 factored by 0.5 and total lands classified as forest lands in the seven counties, which approximate 69,650 hectares (172,100 acres). Under Scenario 2.11, 5.7 percent of these lands will be mined during 1977-85 and 10.5 percent during 1977-2000. Under Scenario 2.11', the respective percentages are 5.7 and 11.7. Factoring these percentages and converting to a scale of 10 results in a "0" impact values for Scenarios 2.11 and 2.11' in the near term and -1 values in the long term (Table 3.8).

Table 3. 8. Impact of Forest Land Depletion

	Hectares/Acres		% Change to 2.15		Effect Rating*		Impact Rating**	
Scenario	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	3,036/7,500	4,818/11,900	0	0	0	0	0	0
2.11	3,967/9,800	7,368/18,200	+27	+53	-3	-8	0	-1
2.11'	3,967/9,800	8,137/20,100	+27	+67	-3	-10	0	-1

Note:

Total forest lands in study area approximate 69,650 hectares (172,100 acres).

*% change to Scenario 2.15 scaled to 10.

**% change to total forest area scaled to 10, factored by 0.5, and rounded to nearest whole integer.

2) Burning (Line 5)

After clearing, burning eliminates all timber resources not previously marketed as timber or pulp wood. The effects are not quantifiable but may be considered to be included under clearing (Line 5). Thus, "0" impact entries over both the short and long terms are made on the matrix for this scenario.

3) Draglining

Draglining to remove phosphate ore is the act by which the effects of depleting the area's phosphate reserves are quantified. The area's phosphate reserves total as 0.941 billion metric (1.037 billion short) tons (TI 1977a). Reserve depletion under this scenario is estimated to be

0.444 billion metric (0.489 billion short) tons for 1977-85 and 0.925 billion metric (1.020 billion short) tons for 1977-2000. Compared with Scenario 2.15, total tonnage mined under this scenario increased 35.5 percent from 1977 through 1985 and 72.0 percent from 1977 through 2000. Under Scenario 2.11', the respective increases are 35.5 and 127.8 percent.

Negative effects ratings represent depletion of resources and are considered exclusive of economic benefits derivable from mining. Numerical values for effects are derived by comparing estimated tonnage to be mined under the various scenarios with the area's total resources as stated in 1977 on a percentage basis setting total resource depletion at -10. This yields the effect ratings presented in Table 3.9; for example, a -8 represents 80 percent depletion of phosphate resources. Comparative impacts are quantified (Table 3.9) on the basis of the changes in effect ratings for the various scenarios compared with Scenario 2.15. Impact values for the depletion of phosphate resources under Scenario 2.11 relative to Scenario 2.15 are -1 over the short term and -3 over the long term. Impact values for Scenario 2.11' are -1 and -5 for the respective terms.

Table 3.9. Impact of Phosphate Resource Depletion

Total Reserves = 941 x 10^6 metric (1,037 x 10^6 short) tons
Total Resources = 1,562 x 10^6 metric (1,722 x 10^6 short) tons

Scenario	Tons x 10^6 Mined		% Change to 2.15		Effect Rating*		Impact Rating**	
	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	327(361)	538(593)	0	0	-2	-3	0	0
2.11	444(489)	925(1020)	35.5	72.0	-3	-6	-1	-3
2.11'	444(489)	1226(1351)	+35.5	+127.8	-3	-8	-1	-5

* Scaled as % of resources where depletion of 1,562 x 10^6 metric (1,722 x 10^6short) tons = -10

** Impact rating equals effect rating difference relative to 2.15

4) Dredging (Line 7)

The use of dredges is scheduled for only one future mine. Thus, effects assessment and impact determinations, this activity is rated inclusively under draglining (Line 5). As a result, the entry on the matrix for this scenario over both the short and long terms is "0."

5) Tailings Placement (Line 14)

Placing this tertiary resource in a mining pit constitutes a positive effect on mineral resources because accessibility is maintained. This scenario creates more sand tailings than Scenario 2.15; the percentage of increase is assumed to be proportional to the tonnage of phosphate ore to be mined. On the matrix, the effects ratings are +3 for the near term and +6 for the long term, consistent numerically with the entries for draglining (Line 6) but opposite in sign. The Scenario 2.11' ratings values would be +3 and +8 for the short and long terms respectively. Because tailings sands are considered tertiary mineral resources, effects ratings are multiplied by 0 to arrive at the impact values entered in the matrix.

6) Slime Placement (Line 15)

Clay-size phosphate particles in the waste clay slime are considered a tertiary mineral resource. The quantity of this resource available under this scenario, when compared with Scenario 2.15, is assumed to be proportional to the production tonnage differences between scenarios. Therefore, effects ratings are consistent with Line 6 but opposite in sign, and the same is true for Scenario 2.11'. Because the fine-grained phosphatic materials in the waste slimes are considered a tertiary mineral resource, "0" impact ratings are entered in the matrix.

7) Waste Placement (Line 22)

Creating gypsum (a tertiary resource) is considered to result in "0" impacts over both the near and long terms for Scenarios 2.11 and 2.11'.

8) Reclamation of Slime Ponds and Mining Pits (Lines 31 and 32)

Reclamation of mined areas using quartz and clay slime materials tends to eliminate those tertiary resources from further consideration as resources. Thus, the effects would be equal and opposite to the acts of creating those tertiary resources (Lines 14 and 15 on the matrix), but the impacts would be "0."

9) Construction Activities (Lines 24-27 and 29)

Constructing dams and levees (Line 24), transportation lins (Line 25), utility lines (Line 26), washing/beneficiation plants (Line 27), and drainage systems (Line 29) under this scenario is expected to increase over 2.15. Seven new mines are anticipated under this scenario; for 2.11', 20 new mines are contemplated. The assumption is that each new mine will utilize a like number of tons of tailings sand for the construction activities and that the effects ratings between the scenarios can be made consistent with the increase in the number of mines; however, because of the minor significance of the use of these tertiary mineral resource for these activities, "0" impacts are entered.

C. SUMMARY OF PRIMARY EFFECTS

1. Natural Environment

a. Atmosphere

The addition of new mines to replace existing capacity will tend to keep the phosphate industry's areawide pollutant load on the atmosphere at a constant level after 1977. Some of the emissions associated with mining, drying, and transporting will shift slightly south as these activities move into Manatee, Hardee, and DeSoto counties. Air emissions created by sources other than the phosphate industry will dominate the inventory in Hillsborough, Manatee, and DeSoto counties so that any changes in air quality will be difficult to associate with the phosphate industry. SO_2 levels in Polk County should slightly decrease as some of the rock dryers are moved south with the mines. Hardee County will exhibit an increase due to the industry move into Hardee. Sarasota and Charlotte counties should not be materially affected by air emissions from the phosphte industry.

The emission inventory will be the same for Scenario 2.11' as for Scenarios 2.13 and 2.14. The general philosophy under which the projections were made is covered in subsection D of Section 2. Changes from the 2.15 inventory occur primarily in the phosphate industry categories covering mining, storage/transportation, and drying. The changes reflect the movement

of these activities from Polk County into Hillsborough, Manatee, Hardee, and DeSoto counties. The emission projections are summarized in Table 3.10.

b. Land

1) Physical

a) Unique Physical Feastures

Unique physical features of interest in terms of potential impact through actions by the phosphate industry are the karst structures that tend to exist in the Hawthorne limestone underlying the phosphate ore zone of the area. The primary effects on these features is expected to be collapse or high-volume drainage caused by excessive surface loading and increased hydrologic head created by abovegrade storage of clay slimes and waste gypsum. The amount or distribution of the waste gypsum stacks for this scenario are not expected to differ from those for the "Without Action" alternative, so interest is focused on the new clay slime impoundments forecast under this scenario. It is estimated that an additional 3,561 hectares (8,800 acres) will be committed to slime impondments from 1977 through 1985 and an additional 11,858 hectares (29,300 acres) from 1977 through 2000. Because the precise locations of karst features underlying the proposed additional mines are not known and detailed information regarding lines of weakness (faults and partings in the underlying limestone is generally lacking, the forecast of regional impact of these abovegrade impoundments is negative but rated "0". The character of the limestone underlying the proposed slime storage areas should be investigated on a site-specific basis to assess the precise potential for impact.

Under Scenario 2.11', additional areas committed to slime ponds are expected to approximate 3,561 hectares (8,800 acres) in the short term and 20,883 hectares (51,600 acres) in the long term.

b) Soils

The 7-county study area possesses approximately 453,264 hectares (1.12×10^6 acres) of mapped soil association containing soil types rated

Table 3.10. Summary of Projected Emissions Under Scenario 2.11

County	Category	Demand Element	Metric Tons per Year TSP 1976	TSP 1985	TSP 2000	SO_2 1976	SO_2 1985	SO_2 2000
Charlotte	Area sources	–	1,862	2,953	4,961	147	234	392
	Point sources							
	Miscellaneous							
	Noncitrus	–	32	51	85	40	64	106
Total			1,894	3,004	5,046	187	298	498
DeSoto	Area sources	–	1,656	2,303	3,179	67	94	129
	Point sources							
	Miscellaneous							
	Citrus	–	29	29	29	85	85	85
	Utilities	–	0	0	4,678	0	0	185,305
	Phosphate							
	Mining/clearing	4	0	4	8	0	0	0
	Storage/transport	12	0	44	160	0	0	0
	Drying	13	0	40	146	0	249	915
Total			1,685	2,420	8,200	152	428	186,434
Hardee	Area sources	–	2,572	3,443	4,831	73	97	137
	Point sources							
	Miscellaneous							
	Noncitrus	–	23	30	43	5	6	8
	Citrus	–	15	15	15	109	109	109
	Phosphate							
	Mining/clearing	4	0	13	29	0	0	0
	Storage/transport	12	0	175	553	0	0	0
	Drying	13	0	160	506	0	997	3,158
Total			2,610	3,836	5,977	187	1,209	3,412
Hillsborough	Area sources	–	12,865	15,498	18,578	2,695	3,246	3,892
	Point sources							
	Miscellaneous							
	Noncitrus	–	1,815	2,186	2,620	7,537	9,083	10,887
	Citrus	–	2	2	2	16	16	16
	Utilities	–	3,831	6,816	7,835	213,218	222,932	233,645
	Phosphate							
	Mining/clearing	4	5	12	10	0	0	0
	Storage/transport	12	1,636	1,636	1,636	0	0	0
	Drying	13	87	302	342	307	1,644	1,893
	H_2SO_4	17	0	0	0	15,946	5,153	5,153
	Fertilizer	18	348	348	348	595	595	595
	Animal feed	19	104	104	104	1,029	1,029	1,029
Total			20,693	26,904	31,475	241,345	243,698	257,110
Manatee	Area sources	–	3,121	4,242	5,814	348	474	648
	Point sources	–						
	Miscellaneous							
	Noncitrus	–	132	179	245	118	161	220
	Citrus	–	164	164	164	0	0	0
	Utilities	–	276	2,211	2,211	3,801	30,407	30,407
	Phosphate							
	Mining/clearing	4	0	14	16	0	0	0
	Storage/transport	12	11	208	339	0	0	0
	Drying	13	0	174	294	0	1,080	1,828
	H_2SO_4	17	0	0	0	1,648	276	276
	Fertilizer	18	32	39	39	24	28	28
Total			3,736	7,231	9,122	5,939	32,426	33,407
Polk	Area sources	–	11,199	14,133	18,452	901	1,137	1,485
	Point sources							
	Miscellaneous							
	Noncitrus	–	586	740	966	318	402	525
	Citrus	–	436	436	436	625	625	625
	Utilities	–	295	965	965	6,987	13,695	13,695
	Phosphate							
	Mining/clearing	4	68	66	13	0	0	0
	Storage/transport	12	4,447	4,447	4,447	0	0	0
	Drying	13	1,178	1,178	214	7,581	7,581	1,330
	H_2SO_4	17	0	0	0	27,699	16,129	16,129
	Fertilizer	18	543	543	543	1,632	1,632	1,632
	Animal feed	19	106	106	106	40	40	40
	Elemental phosphorus	20	335	335	335	832	832	832
Total			19,193	22,949	26,477	46,615	42,073	36,293
Sarasota	Area sources	–	2,901	4,100	5,871	349	494	706
	Point sources							
	Miscellaneous							
	Noncitrus	–	114	162	232	175	246	354
Total			3,015	4,262	6,103	524	740	1,060

high in their potential to produce truck crops or citrus. This represents approximately 28 percent of the study area. Under this scenario, approximately 6,625 hectares (16,370 acres) of these associations are forecast to be destroyed during 1977-2000 and 12,906 hectares (31,890 acres) during 1977-2000. These figures represent 1.5 and 2.8 percent respectively of the total high-potential associations in the study area and compared with the "Without Action" scenario, an increase in the destruction of high-potential soils (relative to the total area) of 0.4 percent (1.1 versus 1.5 percent) for the near term and an increase of 0.9 percent (1.9 versus 2.8 percent) for the long term. Based on these percentages, the impact of this scenario on the destruction of high-potential soils, when compared with Scenario 2.15 is considered negative but is rated "0." The percentage changes of Scenario 2.11' over Scenario 2.15 relative to the total area are 0.4 percent (1.1 versus 1.5 percent) and 1.4 percent (1.9 versus 3.3 percent) for the respective time periods.

c) Exposure

Primary industry activities that exposure the geologic section are drilling (prospect and well drilling) and excavation (draglining and dredging). Scenario 2.11 calls for an additional seven mines to be in operation during the period through 2000, representing an increase of 41 percent numerically over the "Without Action" alternative. Mining plans for six of these imply significant knowledge of the section in the areas, and it is assumed that information from prospect drilling is available also for the seventh location. The additional information that mining (excavating) is expected to provide is not expected to be significant. Thus, the impact of additional industry actions under this scenario is considered to be "0" in both the short and long terms.

For Scenario 2.11', 12 new mines (excluding one scavenger operation) are forecast over Scenario 2.11, all expected to come on line between 1985 and 2000 (Plate 1 in pocket). Compared with Scenario 2.15, 2.11' represents an increase of 112 percent numerically. Section information needed to prepare for these additional mines will constitute a significant

addition to current knowledge, especially in terms of phosphate reserves and resources for these areas. Thus, the impact could be significant; however, because no model exists to rate this significance, "0" impact ratings are assigned.

d) Topography

Land excavation, storage of materials and wastes, and the earthen structures associated with these activities impart primary effects on topography. Land excavation preominates. Comparing Scenario 2.11 with 2.15, the mining of an additional 7,160 hectares (17,600 acres) is expected from 1977 through 1985 and an additional 23,810 hectares (58,500 cres) from 1977 through 2000. This represents an increase of 35.8 and 72.6 percent respectively over Scenario 2.15. However, comparing area increases to the total study area (an estimated 1.6×10^6 hectares [4.0×10^6 acres]), the differences are 0.4 and 1.5 percent for the respective time periods. Because of these low net percentage changes, this scenario's impact on topography is considered insignificant in both the short and long terms. Under Scenario 2.11', the net percentage changes would be 0.4 and 2.6 percent respectively.

e) Background Radiation

Under Scenario 2.11, background radiation levels at the chemical processing plants are expected to remain constant at the current level through the year 2000 because of the continued use of locally mined phosphate ore and the constant level of throughput that is forecast. Therefore, industry effects on background radiation are keyed to activities at the mining sites.

All radiation exposure generally is considered harmful, and adverse effects are assumed to be proportional to dose; in other words, a linear theory rather than a threshold hypothesis is accepted. However, impact determinations must necessarily be based on guidelines or standards normally based on scientific principles tempered by value judgments and tradeoffs. Two direct pathways of exposure to phosphate industry employees and the general population are considered significant: external radiation

exposure from gamma radiation (whole-body exposure) and exposure received by inhaling airborne radionuclides in the form of dust (lung exposure). Occupational guidelines state that employees should not receive a whole-body exposure of more than 5 rem (5,000 millirem) per year or lung exposure of more than 15 rem (15,000 millirem) per year. Guidelines for the general population are one-tenth of these values. To date, no activity of the phosphate industry has been proven to cause a radiation dose to the general population in excess of the guideline; thus, no impact has been shown. Furthermore, when industry average time-weighted values are used, it is anticipated that no phosphate workers will receive doses of radiation exceeding the guideline established for the general population.

Mining and reclamation increase background radiation levels. The magnitude has been estimated on the basis of radium-226 radioactivity concentrations in surface materials expected to exist at various stages for a hypothetical mining unit. Using the conversion factor that an individual will be exposed to 1.85 microroentgens per hour of gamma radiation for each picocurie per gram of radium-226 radioactivity concentration of a surface, the maximum annual dose equivalent for continuous occupancy (values in parentheses on the illustration) in the mining pit (an absurd situation) would be less than the guide for the general population.

Based on the preceding, the impact on the general population and on phosphate workers by the increase in background gamma radiation resulting from the forecast increased mining activity under Scenario 2.11 and 2.11' through the year 2000 would be insignificant compared with that under Scenario 2.15. (Potential impacts of a secondary nature on the general population because of increased mining activities are discussed in subsection D of this section.)

f) Noise

Increased mining activities under Scenarios 2.11 and 2.11' will increase ambient noise levels locally, particularly in the immediate vicinity of operating engines or machinery (e.g., bulldozers, draglines, and

washing/beneficiation plants). These increases will not impact the general population, and employees may be readily protected from these noises.

2) Biological

The mining of wetlands, mixed forest, and deciduous forest, because of their important to surrounding ecosystems and their uniqueness, is considered worst-case. Approximately 6 percent (10,850 hectares, or 26,800 acres) of the present areawide wetlands extent will be mined by the year 2000. Although unrealistic projections of future areawide wetlands extent preclude estimating areawide change attributable to mining, indications are that greatest depletion will occur in the mining area. The loss of only several hundred acres of mixed and deciduous forest types (sandhills, sand pine scrub, and hammocks) will severely deplete the unknown but undoubtedly limited extent of these important habitats.

By the year 2000, mining will account for 69 percent of the projected 18 percent areawide loss of forest (primarily evergreen), 62 percent of the projected 4 percent areawide loss of rangeland, and 85 percent of the projected 7 percent loss of pasture and cropland. The severe impact of mining pine flatwoods is tempered by the projected remaining areawide extent of the type, as well as by the fact that unmined, unmanaged rangelands possibly could succeed to pine forest. The level of impact associated with mining rangeland will depend on the amount of true dry prairie included - and apparently, there is little. The impact of mining pasture and cropland is considered to be negligible. Of the 55,789 hectares (137,800 acres) of uplands/wetlands habitat to be mined by 2000, as much as 16,599 hectares (41,000 acres) will be permanently displaced by water. Water bodies created during reclamation are, like the terrestrial habitats, generally inferior as wildlife habitat to those that could develop were the mining areas merely abandoned.

The impact of noise, dust, and gaseous and particulate emissions is largely unquantifiable, as is the impact of surfce- and groundwater changes and erosion. Of prime concern are the effects that the alteration

of water regime and sedimentation has on the remaining wetlands; these are not addressed to the extent of similar effects on water bodies. Most effects pertinent to habitat quality are claimed to be temporary and not of sufficient magnitude to prevent recovery; actually, however, long-term effects (e.g., reduced carrying capacity) that preclude complete recovery are quite possible.

Since phosphate mining will account for most of the expected area-wide change in land use by the year 2000, it also will account for most of the change in community structure. Particularly will the modified habitat types replacing forests and wetlands support a smaller variety of biota and be considerably less productive in terms of life support. Mining will expand within or into the five counties (Polk, Manatee, Hillsborough, Hardee, and DeSoto) that are already most highly modified by urbanization, industrialization, and agriculture. There will be an increase in the proportion of managed systems that require expenditure of energy to natural systems that do not. The regional carrying capacity, which is the ability of the regional environment to sustain particular levels of activity, may be stressed.

Loss of uplands forested habitat primarily will have the greatest impact on threatened and endangered species that likely will be affected by mining. Actual or potential impacts are considered worst-case for the Florida mouse, short-tailed snake, sand skink, and Florida Scrub Jay because of their endemic status, limited distribution in the study area and state, and restricted habitat (scrub). Impacts on the Florida gopher frog and Southeastern American Kestrel could be severe: the widespread but local kestrel could be eliminated from the region if major concentrations within or near the mining areas were substantially reduced. Moderate to substantial impacts are expected on six other species - the gopher tortoise, eastern indigo snake, Sherman's fox squireel, Wood Stork, Florida Sandhill Crane, and Southern Bald Eagle. Mining will directly reduce populations of some of these species and, coupled with reclamation, will limit opportunities for all of them. They generally are widespread in the study area and equally or more abundant in areas not affected by mining.

Loss of forests (and in this case, particularly wetlands) will have the greatest impact on ecologically significant species. Some of the water-oriented species may utilize shallow mining pits and vegetated slime ponds, but these habitats are displaced during reclamation. Permanent population declines are expected among most of the affected species.

The impact on the hunting and trapping potential of commercial and recreational species is considered minimal, as is the impact of increased abundances of nuisance and pest species. Both of these groups are intensely managed, and increased costs of management undoubtedly will accompany changes in land use. The impacts could be greater than minimal, but a more accurate assessment is difficult without cost estimates.

c. Water

1) Water Quantity

Scenario 2.11 projects future pumpage for existing mines, permitted mines, chemical plants, and proposed new mines in the area. Figure 3.3 shows pumpage duration and magnitude for the proposed mines. These pumpage data (along with those in Figure 2.3) were entered in the USGS model.

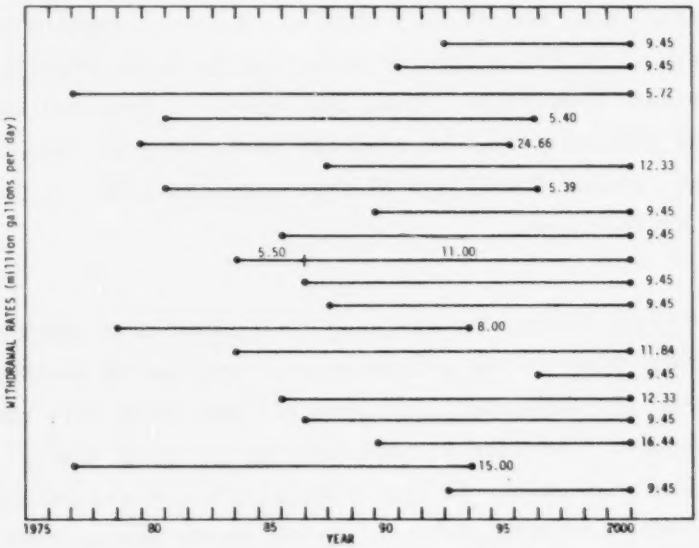


Figure 3.3. Projected History of Groundwater Withdrawals for Proposed Phosphate Mines. (Data for projected withdrawal rates and life spans of mines from TI 1977e)

The model predicted water-level changes in 1985 and 2000 with respect to the September 1975 potentiometric surface of the Floridan aquifer. These water-level changes will also affect the hydrologic system by increasing induced recharge from the water table to the Floridan aquifer, for example, and possibly causing subsequent reductions in streamflow. There will also be an economic effect: a rise in level will reduce pumping costs; a decline will increase pumping cost. A change in the potentiometric surface in the coastal zone might also affect the movement of the saltwater/freshwater interface in that area.

The water-level changes are discussed in the following paragraphs.

Water-level change for 1985 indicates an approximate 1-foot rise in the potentiometric surface in the Bartow area and a decline of about 10 feet in the Four Corners area. This pattern of decline is quite likely, since phosphate mining activities are expected to shift from southwestern Polk County in a south-southwesterly direction toward Manatee and Hardee counties. Not only will there be a 10-foot decline in the Four Corners area but also in small areas near Myakka Head, Bowling Green, and Ona. A 5-foot decline will extent from southeastern Hillsborough County through the middle and western parts of Manatee County into and across the middle of Hardee County and the southern half of Polk County. A 1-foot decline will parallel most of the coast in Hillsborough, Manatee, and Sarasota counties, extending as far south as Port Charlotte. Thus, the effect of proposed and existing phosphate mining generally will be over the whole Central Phosphate District, a decline ranging from 1 and 10 feet compared with the September 1975 potentiometric surface level.

Water-level change for the year 2000 shows that there will be an approximate 20-foot rise in the potentiometric surface in southwestern Polk County relative to the September 1975 levels. This rise will occur in an area south of Bartow. The rise is explained by the fact that a large number of the present phosphate mines in that area will be phased out by the year 2000. At that time, the major activity in phosphate mining will shift in a southerly and southwesterly direction into western Manatee County, into the

middle and southern parts of Hardee County, into the middle and southern parts of Hardee County, and onto the northern part of DeSoto County. This movement will be reflected by a decline of approximately 10 feet in western Manatee County and eastern Hardee County. Additionally, two small 10-foot declines are predicted near Ona and Sandy. In comparing 1985 with 2000 it is interesting that despite the increase of phosphate mining the predicted 1-foot decline in the potentiometric surface is still at the same location (i.e., along the coast in Hillsborough, Manatee, and Sarasota counties).

Again, it should be emphasized that the water-level changes reflect only the changes in activities of the phosphate industry. The results might be quite different if pumpage changes caused by municipalities and agriculture were entered into the model.

In summary, it appears that the largest predicted effect under Scenario 2.11 will be a drawdown of approximately 10 feet, relative to 1975 levels, in western Manatee County in the year 2000.

2) Water Quality

a) Radiological

There are no data with which to determine the radiological impact on the general population as a result of any changes in the radionuclide content of surface, water-table, or aquifer (upper and lower Floridan) waters due to industry activities. For information relative to radium-226 radioactivity concentrations in these waters, the reader is asked to refer to the corresponding discussion in Section 2.

b) Other Water Quality Parameters

The primary effects under the conditions of this scenario are essentially the same as those discussed in conjunction with the "Without Action" alternative, but with increased concern for surface-water degradation caused by clearing, burning, and dam and levee construction. Additional concern for the water quality of the Floridan aquifer is warranted

because of the projected increased amount of injection of wastewaters as mines attempt to meet the New Source Performance Standards.

3) Biological

Primary effects of phosphate-industry activities projected for Scenario 2.11 will be similar in types and magnitudes to those described for Scenario 2.15.

2. Man-Made Environment

a. Land Use

Assessment of the impacts of mining on the environmental elements - in this case, land tenure, community/regional plans, and land use - are largely judgmental but in almost every case are in the same direction (positive or negative) as the effects listed for the "Without Action" alternative. Impacts on land uses are measured both by the areal displacement of land uses by mining and the overall effects on the total land system by displacement and subsequent reclamation.

Forests, agriculture, and open space will be areally displaced, resulting in negative impacts. These land uses are as important from the standpoint of wildlife and general habitat as for the economic value of their potential products (timber, cattle, etc.). Therefore, the impact of their removal is based on the loss of their economic as well as ecological values.

Current reclamation practices have a negative impact on forests and open space, since these are not usually replaced. Reclaimed lands are most commonly used for improved pasture. This reclamation pattern will have a positive (economic) impact on agricultural land but a negative impact on forests and open space.

Mining's impacts on residential, commercial, and industrial lands will be pasture. Increased mining under this scenario will stimulate economic growth, which will probably result in areal expansion of these land uses. Residential land, however, is probably the land use most sensitive to any pollution, noise, or aesthetic degradation created should mining be located in close proximity. If mining occurs within several miles of residences, negative impacts are likely.

The "Permit Existing and New Sources" alternative will have a positive impact on the land use "mining." Compared with the "Without Action" alternative, the conditions of the scenario include a projected 39 percent increase by 1985 and a 60 percent increase by 2000.

b. Archeological, Cultural, Historical, and Recreational

More archeological and historical sites would be destroyed under the conditions of this scenario than under those in the "Without Action" scenario: five more sites would be destroyed by 1985; and 18 more by 2000 (Table 2.18). The impact would be catastrophic, since irreplaceable historical resources would be lost.

Recreation would be both positively and negatively impacted: the increased mining under this scenario would increase the posibility of accidental waste spills and resultant water pollution - and negative impact; and reclamation would increase hunting potential for most waterfowl - a positive impact. Loss of habitat associated with current reclamation practices would have a egative impact on the hunting potential for land-based game species.

c. Demography, Economics, and Cultural Resources

The conditions of Scenario 2.11 would impact the area's economics and the demographic and cultural elements as described in Section 2,B.2.c.

With respect to transportation, a special note is worthy of repeating as reported in the Final Environmental Impact Statement, Tampa Harbor Project (U.S. Army Corps of Engineer 1974):

> "From available data and coordination with the state geologist, it is estimated that there are from 26 to 30 billion tons of phosphate rock deposits in Florida, of which about 2.5 billion tons are considered marketable reserves using existing mining methods and present market and price conditions. About 1.5 billion tons of the marketable phosphate is in Polk County and adjacent areas. This estimate is substantiated by the Florida Phosphate Council. Another billion tons of marketable phosphate is located in Hernando, Citrus, Marion, Levy, and Alachua counties, which, if developed, would require use of facilities at Tampa Harbor for shipment to areas of consumption. It is estimated that about 1.65 billion tons of phosphate would be shipped from Tampa Harbor during the 50-year life of the project - an average of about 33,000,000 tons per year. In addition, there would be production of phosphate for domestic consumption of about 7,000,000 tons per year which would not use facilities at Tampa Harbor."

A letter from the Florida Department of Transportation (March 24, 1974) included in the above referenced environmental impact statement points out that "... with larger vessels utilizing the harbor facilities, there could be a significant increase in both truck and rail traffic, as well as additional auto traffic generated by the enlarged labor force." The letter also points out the existing condition of "the situation of long freight trains bringing phosphate to Port Sutton, delaying traffic on SR 45 (US 41). This expansion can only augment the present problem."

d. Resource Use

1) Timber

The 7-county study area possesses approximately 69,650 hectares (172,100 acres) of lands mapped as forest lands. This study classifies timber as a secondary resource, and it is lost when forest lands are cleared in preparation for phosphate mining and attendant activities. Under this scenario (2.11), it is estimated that these activities will involve more than 3,966 hectares (9,800 acres) of forest lands during 1977-85 and more than 7,366 hectares (18,200 acres) from 1977 through 2000, an increase over the "Without Action" scenario (2.15) of 27 and 53 percent respectively.

Under Scenario 2.11', mining forecast in forest lands during 1977-85 equals that under Scenario 2.11. For the 1977-2000 time period, an increase of 67 percent over the "Without Action" scenario is forecast.

Mining under this scenario from 1977 through 1985 is estimated to involve the destruction of 5.7 percent of the total timber resources of the study area; from 1977 through 2000, 10.6 percent will be destroyed. This will increase depletion over the "Without Action" alternative by 1.3 percent in the short term and 3.7 percent in the long term. Under Scenario 2.11', the percentage destruction of forest resources of the study area will be 5.7 and 11.7 percent respectively for the 1977-85 and 1977-2000 time periods, representing depletion increase over the "Without Action" alternative of 1.3 percent for the short term and 4.8 percent for the long term. Such a loss will not cause a significant impact, however, since timber areas to be mined under this scenario is small relative to total timber area in the study area.

2) Phosphate

The study area's total phosphate resources have been estimated to be 1,596 x 10^6 metric (1,722 x 10^6 short) tons, which includes known reserves totaling 940.6 x 10^6 metric (1,037 x 10^6 short) tons. Phosphate ore mined under this scenario is estimated at 0.444 billion metric (0.489 billion short) tons during 1977-85 and 0.925 billion metric (1.020 billion short) tons during 1977-2000. Compared with the "Without Action" scenario, total tonnage mined under this scenario represents an increase of 35.5 percent for the short term and 72.0 percent for the long term; the conditions of Scenario 2.11' would increase production an estimated 35.5 and 127.8 percent respectively.

In terms of depleting the area's known phosphate resources, Scenario 2.11 poses an increase over the "Without Action" alternative of 7.5 percent in the near term and 24.8 in the long term; for Scenario 2.11', the increased depletion percentages would be 7.5 and 44.1 percent respectively. These percentages were developed from the data in Table 3.11.

Table 3.11. Phosphate Rock Production Forecast for Scenarios 2.15, 2.11, and 2.11'

	Tons Mined x 10^6		% of Resources*		% to 2.15**	
Scenario	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	361	593	20.9	34.4	–	–
2.11	489	1,020	28.4	59.2	7.5	24.5
2.11'	489	1,351	28.4	78.5	7.5	44.1

*Resources = 1,722 x 10^6 short tons (Reserves = 1,037 x 10^6) short tons).

**Change in percentage value relative to Scenario 2.15.

D. SUMMARY OF SECONDARY EFFECTS

1. Natural Environment

a. Atmosphere

No secondary effects were quantified in this category.

b. Land

1) Physical and Chemical

Secondary effects of phosphate industry activities under this scenario will be similar to those discussed in Section 2 except for slight changes in magnitude that cannot be quantified. Additional acreage forecast to be mined under this scenario is predominantly in sparsely populated areas, so any mining-induced changes in background radiation within the levels forecast in subsections C and D.2.e in this section would be expected to have little impact on the general population.

2) Biological

Secondary effects of phosphate industry activities projected for Scenario 2.11 will be similar in types and magnitudes to those described for Scenario 2.15.

c. Water

1) Water Quantity

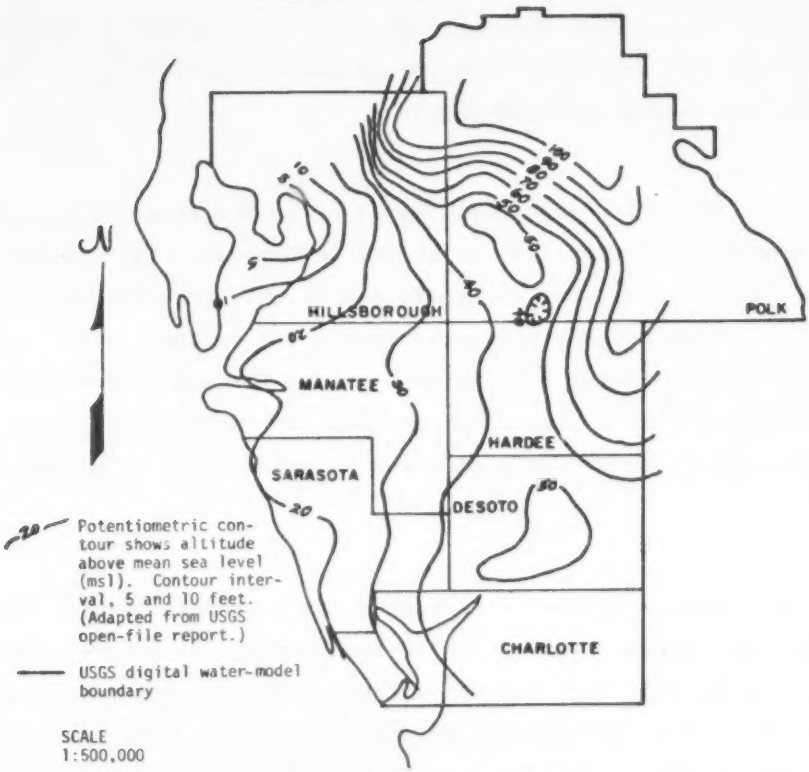
a) Scenario 2.11' Assessment

To assess the effect of Scenario 2.11' on the hydrologic system in terms of secondary effects, a potentiometric surface map for September 1985 was prepared (Figure 3.4) by combining calculated water-level changes for that period with a September 1975 potentiometric surface map. These changes were calculated using the USGS model.

The 20-foot contour will still be in the same location in the coastal zone in September 1985 as it was in September 1975, indicating that no change in the potentiometric surface will have occurred in the coastal area. The 30-foot contour line will have moved farther to the east, thereby creating a somewhat large spacing between the 20- and 30-foot contours. This indicates a flattening of the gradient of the potentiometric surface toward the coast, suggesting a decrease in groundwater flow toward the Gulf of Mexico.

A positive effect is indicated for southwestern Polk County; there, the area encompassed by the 50-foot contour will have creased considerably, indicating that the water level will have risen in those areas. This rise will have a beneficial secondary effect in that well-owners in the area will be spending less money on pumping because pumping lifts will have decreased.

As mentioned previously, the model used has a constant source and does not predict changes in the head of the water-table aquifer itself. Therefore, the impact of proposed phosphate mining activities on the water table and on water-dependent vegetation cannot be assessed. However, experience has indicated that the effects can be expected to be minimal because the confining beds are relatively impermeable and thicken toward the south. An adverse economic effect of the proposed development in Sarasota, Manatee, and to some extent in southern Hillsborough County in 1985 will be the increased costs to well owners owing to increased pumping lifts. Also, the



NOTE: Contours reflect September 1975 surface modified by changes in phosphate industry withdrawal rates only.

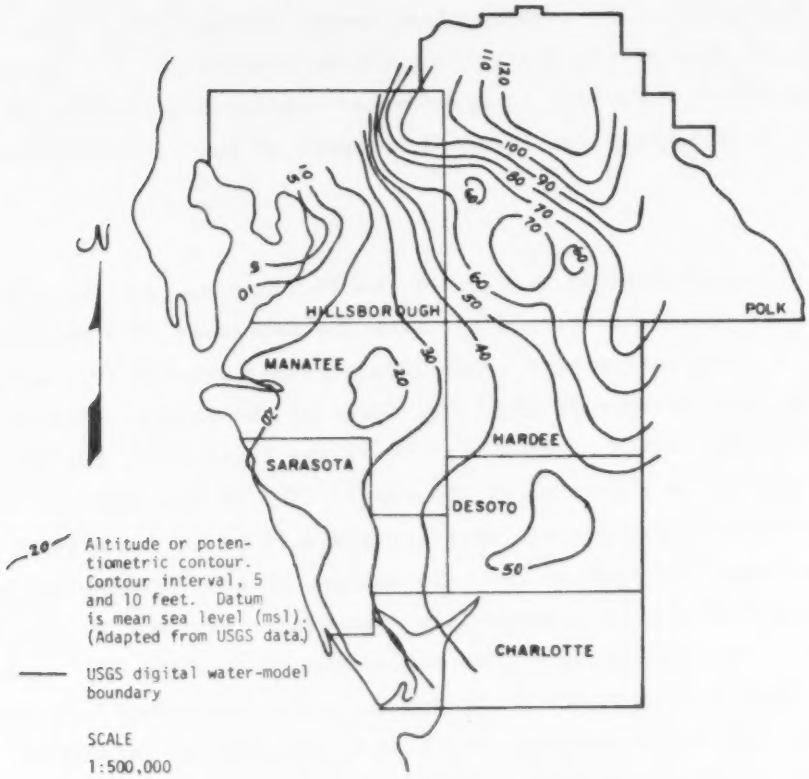
Figure 3.4. Simulated Potentiometric Surface, September 1985, under Scenario 2.11'

potential for upconing of mineralized water from the deeper zone of the Floridan aquifer will be increased. This will be most prevalent in old wells that have been drilled into the lower, more mineralized zone of the Florida aquifer and have been abandoned without being plugged.

In regard to the problem of saltwater encroachment in the coastal zone, the flattening of the hydraulic gradient between the 20- and 30-foot contours suggests a reduction in groundwater outflow and, theoretically, an increase in the potential for landward movement of the salt/freshwater interface.

The potentiometric surface of the Floridan aquifer for September 2000 (Figure 3-5) was constructed by using the September 1975 potentiometric surface map in combination with water-level changes between 1975 and 2000. There will be some changes in the inner parts of the Central Florida Phosphate District and, again, shifts will be in the location of the 20-foot contour in only a few places along the coast. The 30-foot contour line, however, will have moved farther eastward and will be in the western part of Hardee County near the town of Ona. In eastern Manatee County, the potentiometric surface will have a plateau-like appearance, as shown by the 20-foot contour line. The flattening of the potentiometric surface will reduce groundwater outflow toward the Gulf, and this most likely will increase the potential for the inland movement of the salt-/freshwater interface. There will also be an economic effect, because the reduction in the potentiometric surface will result in increased pumping lifts and pumping costs in certain areas.

In summary, future development of the phosphate industry, according to Scenario 2.11', will generally lower the potentiometric surface of the Floridan aquifer in the western part of the Central Florida Phosphate District. However, the predicted declines are very small compared with the total thickness of the freshwater zone (a 10-foot decline compared with a thickness of 1,500 feet).



NOTE: Contours reflect September 1975 surface modified by changes in phosphate industry withdrawal rates only.

Figure 3.5. Simulated Potentiometric Surface, September 2000, under Scenario 2.11'

No adverse effects except the small increase in pumping costs and the increased potential for saltwater encroachment are expected from future pumping of the Floridan aquifer by the phosphate industry. The validity of these predictions, of course, depend on the validity of the water-level changes predicted from the aquifer model designed and constructed by the U.S. Geological Survey.

b) Comparative Effects Assessment

The groundwater pumpage described for Scenarios 2.15 and 2.11' reflect a minimum-maximum approach to the effects assessment. Scenario 2.15 represents the minimum groundwater pumpage conditions expected, and Scenario 2.11' represents the maximum conditions.

To evaluate the difference between two scenarios' effects on the water levels of the Floridan aquifer, that the difference in effects of the two scenarios on the potentiometric surface will be, at most, 20 feet at the Manatee-Hardee county line north of the Myakka head. Comparison of this value with average seasonal fluctuations in the potentiometric surface of 30 to 40 feet in the area leads to the conclusion that a 20-foot difference is not a major effect with regard to Scenarios 2.15 and 2.11'.

To estimate the economic effect of the difference between the two scenarios, it was assumed that the cost of lifting 1 acre-foot of water (325,900 gallons) a distance of 1 foot is 2.6¢ for a pump working at 80 percent efficiency. For example, the difference in economic costs to pump at a rate of 10,000,000 gallons per day in the northeastern corner of Sarasota County has been calculated: the difference in water levels is approximately 7.5 feet and the difference in the cost of lifting the water is $2,184 per year (the year 2000); the annual cost difference for a well-owner pumping at the same rate in the area north of Myakka head will be $5,824.

c) Comments

The digital model used to simulate effects is in early stages of refinement; therefore, the reliability of the predicted water-level changes

must be viewed as "underestimated." If the changes are reasonably valid, the overall conclusion is that the effects on the potentiometric surface of the Floridan aquifer resulting from the projected pumpage under Scenario 2.11' will not be of major importance. However, final judgment on the effects should await the model runs of the combined future changes in pumpage for municipalities, agriculture, and all other industries. In addition, the validity of some of the model parameters used to predict the water-level changes require substantiation. As these refinements are made, fresh simulation runs should be made and evaluated relative to the outputs usd for impact analysis in this program.

2) Water Quality

A secondary effect under the conditions of this scenario (2.11) is the increased potential for pollutional loads covered by the failure of slime-pond dikes. This potential becomes particularly significant under this scenario inasmuch as a slime-pond break would threaten the water quality of Class-I waters.

3) Biological

Secondary effects of phosphate industry activities projected for Scenario 2.11 will be similar in types and magnitudes to those described for Scenario 2.15.

2. Man-Made Environment

a. Land Use

The effects discussed in subsection C.2.a of Section 2 are applicable under this scenario (2.11) as well.

b. Archeological, Cultural, Historical, and Recreational

The effects discussed in subsection C.2.b of Section 2 are applicable under this scenario (2.11) as well.

c. Demography, Economics, and Cultural Resources

Attention is invited to previous comments on effects under the "Without Action" alternative (Scenario 2.15). Continued holdings of large tracts of land by the phosphate industry on the north-south axis from Lakeland to Port Charlotte will continue to increase population density in the development crescent from Lakeland to Tampa and along the coast. Accelerated phosphate mining under Scenario 2.11 could increase inflated land values more, deplete nonrenewable resources, and further reduce the amount of land in agricultural production. Adverse environmental damage such as despoiled landscapes or incompatible land usage could result. There is every reason to believe that increased mining activity could also impact unfavorably on the multimillion-dollar tourist-recreation industry by reducing or altering the scenic attraction of the area.

On the positive side for the phosphate industry, industry holdings of land will effectively prevent large-scale development of the hold land for at least the next 25 years. This reclaimed land will then be available for phased development at a time when it is most needed to relieve coastal population congestion.

Table 3.12 projects by scenario the economic impact of the phosphate industry on the study area. As indicated, the industry's continued development will result in about 10,000 direct and almost 62,000 induced jobs in the study area by 1985, declining to about 8,100 direct jobs and 50,000 induced jobs by 2000. Total payroll attributable to the phosphate industry will be about $340,000,000 in 1985, declining to about $274,000,000 by 2000.

d. Resource Use

No secondary effects on resource use are identified relative to phosphate industry activities specific to this scenario. The reader is asked to rfer to the summary of secondary effects on resource use discussed in Section 2, subsection D.2.d.

Table 3.12. Projected Economic Impact of Phosphate Industry on Study Area by Scenario, 1980-2000

Year	Scenario	Production (million short tons)	Phosphate Industry Employment*	Phosphate Industry Payroll** (000,000)	Induced Employment***	Induced Payroll**** (000,000)
1975	Actual†	38.2	8,512	65.8	52,349	221.3
1980	2.11‡	41.2	9,181	71.0	56,463	238.7
	2.15‡	42.2	9,403	72.7	57,828	244.4
1985	2.11‡	45.2	10,072	77.9	61,943	261.9
	2.15‡	33.2	7,398	57.2	45,498	192.4
1990	2.11‡	44.8	9,983	77.2	61,395	259.6
	2.15‡	27.5	6,128	47.4	37,687	159.3
1995	2.11‡	42.0	9,359	72.4	57,558	243.4
	2.15‡	9.1	2,028	15.7	12,472	52.7
2000	2.11‡	36.5	8,133	62.9	50,017	211.5
	2.15‡	2.6	579	4.4	3,560	15.0

*Based on 1975 average of 222.84 workers per million tons produced.

**Based on 1975 average of $7,742 per worker per annum, 1967 constant dollars.

***Based on Bureau of Mines estimates of 6.155 jobs generated for each new job in the phosphate industry.

****Average of $4,228 per worker per annum, 1967 constant dollars.

†U.S. Bureau of Mines (1975) adjusted by Texas Instruments for the study area; Florida Statistical Abstract (1976).

‡U.S. Bureau of Mines (1977) adjusted by Texas Instruments.

‡Texas Instruments projections of production from existing mines.

SECTION 4

REQUIRE PROCESS MODIFICATIONS FOR NEW SOURCES

A. DESCRIPTION OF ALTERNATIVE

The process modifications listed under this scenario are practical and feasible, as evidenced by their use by present phosphate industry operators, except for the last one - impervious lining for recirculated process water ponds at chemical plants. For the purposes of the central Florida phosphate industry areawide impact assessment program, this scenario is considered to be applicable to those operations under Scenario 2.11 not permitted as of 1 August 1976. Operational descriptions of each proposed modification for the purposes of impact assessment follow.

1. Elimination of Slime Ponds

The beneficiation of mined materials is required to separate as much as possible the phosphate from the nonphosphate. The process results in two waste materials: slimes (waste clays) and tailings (sand). Control and management of the latter are not an environmental problem, but the disposal of slimes is. Conventional methods involve large settling areas (30-60 percent of mined lands), and reclamation to support agricultural uses requires 5-20 years and cannot be used for industrial or commercial development involving structures larger than most single-family dwellings. Thus, the phosphate industry's temporary use of the land becomes less temporary, depending on the desired land use category subsequent to the mining activities. Other environmental problems are caused by slime pond dam breaks (the most recent in 1971 on the Peace River), pipeline or drainage-ditch breaks (the most recent in August 1977 on the Alafia River), and discharges of inadequately settled slimes. The clay particles clog the gills or other membranous surfaces of aquatic organisms, preventing oxygen transfer.

There are two lines of strategy for eliminating slime ponds: one involves a change in process procedures; the other, a change in reclamation

procedures. The most recent literature regarding the former describes a dry-mining calcination-digestion process (EPA 1976). The concept involves dry mining the matrix, upgrading by dry methods, calcination, digestion to produce phosphoric acid, and returning gypsum and acid-insoluble byproducts to the mining pits. If successfully implemented, the process would result in closed-loop operation involving the disposal of all of the major mining and chemical plant byproducts in mine pits without aboveground dikes and ponds, the utilization of at least 90 percent of the actually mined phosphate values, a major reduction in the deep-well water makeup requirements, and complete elimination of slime-pond environmental hazards and potential fluorine runoff, leaching, and evaporation from gypsum ponds.

Bench-scale studies were performed cooperatively among the EPA (Region IV and Research Triangle Park), USS Agri-Chemicals, and the Minnesota Minerals Research Center. Results using matrix samples reflecting major types of phosphate deposits found in the Florida Bone Valley formation were as follows.

- Matrix Upgrading

  This was required in order to minimize fuel costs of the calcination process and to eliminate some of the metal impurities such as iron, aluminum, and magnesium. Methods other than wet scrubbing require a nearly dry matrix. Because of the high water table found in central Florida, matrix deposits contain 30-60 percent by weight water. Drainage of the water from the matrix is generally poor, depending on the clay content. Piling aboveground results in draining to only 20 percent by weight water. Thus, to dry process, matrix must be dried (a costly energy-consuming process). To remove inert components such as sand in order to reduce the mass to be calcined after drying, an electrostic technique was used. However, clay particles coating phosphate particles caused interference. An alternative process demonstrated feasible by W.R. Grace and Company combined drying and grinding in a vertical attrition column in which a high-velocity airstream was recirculated and dust (clay) and matrix separated at the top in cyclones. Sand in the phosphate fraction was separated by electrostatic treatment.

- Calcination and Digestion

  Current processes recover about 65 percent of the total P_2O_5 value from the matrix. The calcination process did not measure

up to this efficiency, primarily because of the solubility of aluminum, which responded least to the treatment but was prevalent in the tested samples.

Because of the technical problems with the solubility of aluminum and the high fuel requirements of upgrading the new matrix, it was recommended that this line of research be discontinued.

For the central Florida phosphate industry areawide impact assessment program, slime elimination seems to be more practically a problem of slime-pond reclamation because of the seemingly dead-end reached by the strategy for modifying the processes used. Thus, TI's attention was directed to the phosphatic clays research program jointly sponsored by the U.S. Bureau of Mines and central Florida phosphate industry operators. Treatment and disposal methods feasible and operational to date to decrease the size and longevity of slime ponds include flocculation to decrease the time interval for settling and dewatering the clays and combining sand tailings and slimes to fill mine cuts (TI 1977a; Bromwell 1976). The solids contents for the sand-clay mixture range from 50 to 90 percent, resulting in landfill suitable for reclamation within 2 years for pasture that will adequately support cattle and farm vehicles. Subsequent subsidence could occur, limiting subsequent land uses to those in which overburden pressures are no greater than those resulting from agricultural production. The sand-clay mixture process is being used by Brewster Phosphates, and the flocculation method is being evaluated at mines operated by Mobil Chemical, Swift Chemicals, and U.S. Steel Agri-Chemicals. The following is an excerpt from a letter written by Richard Timberlake, plant manager of Brewster Phosphates, to the EPA:

> "With regard to the sand-clay mix which we have adopted for our reclamation technique, I would not say we have 'eliminated slimes ponds,' but we are restricting our enclosing dams to about 4 feet above level ground and are attempting to confine our clay and sand waste disposal to mined-out cuts. A brief description of the Brewster Phosphates technique follows:

Waste Disposal and Land Reclamation

"There are three waste products generated in the mining of phosphate rock in Florida: overburden, phosphate clays, and sand. The overburden and sand tailings offer no particular disposal problem except one of volume. Phosphatic clays are approximately 80 percent minus 20 microns and enter the settling reservoirs as 3-5 percent slurry. Historically, some 65 percent of mined lands have been transformed into settling areas for disposal of waste clays. The settling areas are surrounded by high dams, and large quantities are stored above natural ground. Reclaiming of settling areas is slow, and the lands restored have very limited use - usually light agriculture or wildlife sanctuaries. In the reclamation technique employed at Brewster Phosphates, most of the waste clays are stored below natural ground, where the phosphatic clays settle to 12-15 percent quite rapidly. By spraying the tailings sand over the consolidated clays, the sand penetrates and mixes with the clays, liberating water and producing a thick sand-clay mixture. After the mixture has consolidated and the excess water is drained off, the overburden is spread over the surface with a wheel excavator and stacker and is graded in a manner which will minimize erosion and facilitate proper site drainage. The land is then fertilized and seeded with appropriate vegetation. By utilizing Brewster Phosphates' method of storing the phosphatic clays below natural ground, a greater percentage of land is available for general purpose or utility use as opposed to light agriculture or wildlife sanctuaries. The lands reclaimed have potentially higher resale value, and liability from possible dam failures is reduced significantly ...

"Dr. Bromwell has followed our sand-clay reclamation work for almost 3 years at Haynsworth Mine. I believe Les can give you a thorough technical opinion of the scheme.

"Costs that are generated in disposing of tailings, water, and clay handling in the field (called circulation and settling) and land reclamation vary widely; however, I believe that the traditional method of handling and disposing of clay plus reclamation will generate a cost of from $0.70 to $1.00 per ton of rock. In our judgment, our sand-clay method will generate the same costs; we see it as a stand-off cost-wise as opposed to the traditional method."

2. Chemical Processing of Wet Rock

For purposes of effects assessment, this process is applicable to that portion of the mined and beneficiated rock to be chemically processed

in the 7-county study area. Wet-rock grinding facilities are in full-scale operation in phosphoric acid plants at the Plant City complex of C.F. Industries, at Agrico Chemical's Faustina (Louisiana) facility, and at both the old and new plants of W.R. Grace's Bartow complex. There are four advantages of wet-rock grinding:

- Capital expense, from receipt of unground wet rock through the point of feeding it into the acid processing system, is reduced by about half.
- Dry-rock dust pollution is eliminated.
- Fuel economy is improved by 2.5 gallons per ton of phosphate rock ground and combines with electrical power savings to reduce operating costs by \$3.00-\$4.25 per ton of P_2O_5.
- Reliability is improved; thus, the required amount of surge of ground rock can be reduced. If a plant is located near a mine, a rock slurry can be pumped directly to the plant from the mine, eliminating rail transportation and belt conveyors (Houghtaling 1975, Loughrie 1976).

3. Dry Conveyor for Matrix from Mine to Beneficiation Plant

The term "dry conveyor" is a misnomer, since the matrix conveyed from the mine to the beneficiation plant is wet. The system in operation at Brewster Phosphates' Lonesome Mine in Hillsborough County is the process referred to here and is described in the following excerpt from a letter to the EPA from Richard Timberlake, plant manager:

Mining

"Mining at the pit follows the conventional method where the dragline removes approximately 24 feet of overburden which is predominately (sic)fine sands with intermittent seams of sandy clay. The dragline then casts the 12-foot strata of matrix into an earthen sump where high-pressure water monitors are used to slurry the matrix for pumping. The matrix, on a dry basis, contains about one-third recoverable phosphate, one-third quartz sand, and one-third phosphatic clays. The material is transported through pipeline up to 7,500 feet to a screening station where +3-inch material is discarded. The -3-inch +3/4-inch material is crushed by a mechanical

impactor and mixed with the -3/4-inch slurried matrix. The -3/4-inch material is pumped another 2000 feet to 48-inch diameter hydrocyclones where the phosphatic clays are removed and pumped to the waste disposal area. The cyclone apex product, at about 70 percent solids, discharges directly onto the conveyor belt where it is transported to the plant for processing.

Transportation

"The overland conveyor belt system consists of 14,500 feet of 54-inch wide steel cable-reinforced belt traveling at a speed of 885 feet per minute. Unlike conventional conveyors which are powered only at the end, this system is powered by intermediate drive modules spaced an average of 1200 feet apart. Energy is transferred from electric motors to the belt by steel-belted radial tires that run on and grip the edge of the belt. Fewer idlers, a less massive terminal structure, and simplified takeups are employed with the new belt system. The matrix discharges off the end of the belt into a tank where it is reslurried and pumped the final 2000 feet to a 3-section washer.

"The belt system will require substantially less electrical energy than a pipeline slurry system. Other savings include lower maintenance cost and significantly lower capital replacement cost over abrasive resistant pipe and associated pumping equipment.

Processing

"At the washer, the deslimed matrix is washed, scrubbed, and screened to produce a clean +20-mesh final pebble product which is about 50 percent of the mine's total salable phosphate values. The -20-mesh material is flotation plant feed and is prepared for flotation in the sizing section. Final preparation of the plant feed is the removal of tramp, +20-mesh material which is returned to the washer, and the remaining -150-mesh clays via bin overflows that report to two 0.550 feet diameter thickeners. The solids settle out in the thickener and are pumped to holding ponds. The clear water is drawn off the periphery of the thickener and reused in the plant.

"Feed to the flotation plant is dewatered to 75 percent pulp density with 24-inch diameter cyclones, then conditioned with anionic reagents. The conditioned feed flows by gravity to 500-cubic-foot mechanical flotation cells where the gangue (sands) sinks to the bottom of the cells and is removed as waste. The froth (rougher concentrate) is collected for further treatment.

"The rougher concentrate is dewatered with cyclones, mixed with water and sulfuric acid, and sent to a series of acid mixers for scrubbing and cleaning to remove the anionic reagent from the surfaces of the feed. From the wash boxes, the second flotation step occurs when cleaner (cationic) float flows by gravity to 500-cubic-foot mechanical flotation cells where the sand tailings float and the phosphate sinks. The tailings sand combines with the waste from the first flotation step and is pumped to the 54-inch overland belt conveyor where 24-inch diameter cyclones are used to remove the water from the solids. The cyclone apex product, at about 70 percent solids, discharges directly onto the bottom strand of the belt and is transported to the waste disposal area. The cyclone overflow flows by gravity into the water-holding ponds.

"That gives you a pretty good idea of how our mine and beneficiation plant is constructed and how it operates. It is not true that water conservation results from the use of the overland conveyor, since matrix is slurried at the pit and pumped to the belt in the traditional method. Desliming occurs near the mining operation, a fact which eliminates long-distance pumping."

The cost of purchasing and installing the Brewster conveyor belt system is 38 percent more than a matrix-tailings pumping system, but annual maintenance and replacement costs are estimated to be 55 percent lower, and power demand is 12 percent that of the pumping system.

4. Recovery of Fluoride from Recirculated Process Water, Including Scrubber Water

Recovery of fluorides from phosphoric acid is in use by USS Agri-Chemicals and W.R. Grace. The net environmental benefit is the recovery of an otherwise waste product as a byproduct. Fluoride emissions from gyp ponds are reduced, as is the amount which must be scrubbed from phosphoric acid reactor emissions. A description of the processes used at USS Agri-Chemicals and W.R. Grace is excerpted as follows from letters to the EPA:

"As a result of development engineering in the late 1960s to generate a means of diluting concentrated sulfuric acid with wet-process phosphoric acid pond water and thereby eliminate production problems with respect to conventional sulfuric acid dilution coolers and simultaneously create a negative water balance in the

phosphoric acid pond water system, an offshoot of this work was devised and a process resulted which would recover fluosilicic acid (FSA) from phosphoric acid.

"Our (USS Agri-Chemicals) process uses 22 percent of P_2O_5 recycle phosphoric acid from the filtration wash steps as a diluent for diluting 98 percent sulfuric acid. The heat of dilution drives off silica (sic) tetrafluoride (SiF_4) from the 22 percent recycle stream, along with water vapor. The hydration product is a 25 percent H_2SiF_6 fluosilicic acid of extremely low P_2O_5 content. Conventional processes for stripping FSA during phosphoric acid evaporation produce FSA containing between 0.5 and 2 percent P_2O_5. Our process consistently produces FSA with a content well below 0.3 and frequently under 0.1 percent P_2O_5 (100 percent H_2SiF_6 basis).

"We installed a commercial unit which became operational in May 1970 as a first of its kind at a total capital cost of $1.5MM. In addition to reclaiming FSA through the recycle acid dilution route, we built certain flexibilities in the commercial plant to innovate recovery of FSA from fluorine scrubber systems from the triple super phosphate (TSP) manufacture and from steam stripping of the final concentrated phosphoric acid. The latter two process adjuncts did not prove satisfactory and have since been abandoned. I cannot project accurately the capital costs of a unit designed and built for recycle acid service only on today's cost basis but would guess at least $2.5MM.

"Since this was an entirely new concept and the process conditions were extremely severe, the operating costs and profit benefits have been considerably less than satisfactory. Mechanical and corrosion problems resulting from the stringent operating conditions have led to prohibitive maintenance costs. The process deals with high-temperature mixes of sulfuric acid and phosphoric acid in an atmosphere of fluoride compounds, all of which contain abrasive, precipitated SiO_2 and calcium sulphate (gypsum). The high temperatures tend to promote the anhydride formation of calcium sulphate, and scaling is a serious problem. We have learned to live with the process and, though it now performs well, it is a costly operation.

"The fluoride recovery system in the W.R. Grace phosphoric acid plant is the Swift & Co. process licensed to Grace by Swift. Fluorides are recovered in the form of hydrofluosilicic acid (H_2SiF_6) of approximate 25 percent strength. The process recovers approximately 65 percent of the fluorine in these vapors as 25 percent hydrofluosilicic acid, which calculates to approximately 25 percent fluorine recovery from the total coming in with the phosphate rock. The vapors leaving the phosphoric acid vacuum evaporators are scrubbed under vacuum with a recirculating solution of hydrofluosilicic acid whose temperature is approximately that of the vapors. Little or no water is condensed while the SiF_4 and HF are absorbed in the fluosilicic acid solution. The lean vapors from the fluorine scrubber are then passed to the usual barometric

condenser for total condensation. A specific gravity controller activates a valve which discharges the H_2SiF_6 to storage when up to the desired strength. Makeup water then flows into the hot well through a float control valve."

Reported costs of fluoride recovery operations exceed prices by 25-36 percent. Fluoride is marketed for the fluoridation of water supplies and as an industrial chemical.

5. Uranium Recovery from All Phosphoric Acid

This process would result in less radioactive material in phosphate products but, since the uranium extraction process occurs after the initial digestion of phosphate rock by sulfuric acid resulting in phosphoric acid and calcium sulfate (gypsum) (see TI 1977a for a schematic of this process relative to uranium values), the gypsum is a waste product and is separated from the process flow. Therefore, gyp piles at chemical processing plants contain radioactive material, as do the slimes resulting from beneficiation and the leach zone overlaying the phosphate rock matrix which is redistributed by the mining and reclamation activities.

Generally, the concentration of uranium in phosphate ore material of the same mesh size in Florida tends to be directly proportional to the P_2O_5 concentration (Guimond 1976). As a rule-of-thumb for planning purposes, a pound of U_3O_8 may be found per ton of P_2O_5 in the types of deposits found in central Florida (Hurst 1977). At a full-capacity operation of 4,570,000 tons per year (Ross 1975), the 12 phosphoric acid plants in operation in the 7-county study area would pass 4,570,000 pounds of U_3O_8 per year (approximately 19.4 percent of 1975 U.S. uranium production). The current price of U_3O_8 is approximately $40 per pound. Cost of recovery from phosphoric acid is approximately $15 per pound. Thus, if all central Florida phosphoric acid plants used uranium recovery at 90-95 percent efficiency, an annual industry of $182,800,000 with costs of $68,650,000 would result - an attractive economic incentive with positive environmental-quality benefits, and the uranium would replace the energy equivalent of from 97 to 129 million barrels of oil (a pound of U_3O_8 is approximately equivalent in energy to 21.7 to 28.2 barrels of oil).

Uranium Recovery Corporation has built a central processing plant near Mulberry with a capacity to handle six extraction modules located at phosphoric acid plants where initial extraction occurs. The concentrate is trucked to the Mulberry plant. Two modules are installed at the W.R. Grace Bartow complex, and two will be in operation soon at IMC's Mulberry complex (Ross 1975, Leaders 1977). Gardinier recently announced intentions to construct in Gibsonton a $15,000,000 plant designed to extract 200 tons of uranium per year. A subsidiary of Westinghouse is developing an extraction facility at Farmland Industries, a pilot plant is in operation at Agrico Chemical in South Pierce, and Freeport Mineral's Uncle Sam (Louisiana) plant which processes Florida phosphate rock is presently extracting uranium at commercial scale (Ross 1975, Leaders 1977).

Guimond (1976) of EPA estimates that eight to ten 1000-megawatt (electric) [Mw(e)] nuclear power plants could be powered by uranium recovered from U.S. phosphoric acid plants; he further states that another 30-40 nuclear power plants [1000 Mw(e)] could be fueled annually if uranium were recovered from mining wastes (slimes and tailings). Brookhaven National Laboratory is researching a process to recover uranium from slime pond waste dumps (Guimond 1976).

6. Impervious Lining for Recirculated Process Water Ponds at Chemical Plants

None of the existing gyp ponds are lined; therefore, operational-scale feasibility and cost data do not exist. There is some merit in examining clays from slimes for lining these process waste ponds. Surface seepage does occur but is collected in perimeter ditches to be pumped back into the ponds. Because of the lack of data on the extent, if any, of surface and subsurface seepage and the feasibility and adequacy of impervious linings to control this potential source of pollution, effects assessment activities did not include an objective and quantitative evaluation of this process modification.

B. MATRIX AND SUPPORTING RATIONALE

1. Natural Environment

a. Atmosphere

Of the process modifications proposed, only one will appreciably affect the inventory of SO_2 and dust emissions generated by the phosphate industry. This process modification involves wet rock processing, which will eliminate emissions now caused by rock drying, dry rock grinding, and dry rock transport and storage, T.D. element 13. The calculated impacts and matrix entries are shown below for Scenario 2.12.

	1985		2000	
T.D. Element	Calc.	Matrix	Calc.	Matrix
4	-0.004	0	-0.002	0
12	-0.111	-1	-0.093	0
13	0	0	0	0
17	-0.322	-1	-0.310	-1
18	-0.070	0	-0.063	0
19	-0.011	0	-0.073	0
20	-0.031	0	-0.028	0

b. Land

1) Physical and Chemical

a) Unique Physical Features

The candidate method for eliminating slime ponds will have a positive effect on the area's unique physical features because of the significantly reduced potential for collapse of karst features, although, according to Kaufmann and Bliss (1977), sinkhole (karst) collapse and similar acute incidents are uncommon or at least not well documented in regulatory agency files.

Lining waste-gypsum stacks and cooling-water ponds at the chemical processing plants is expected to reduce seepage into the underlying strata. Such seepage has been suspected of enlarging lines of parting in the underlying karst structures. Because of the neutralizing characteristics of the underlying carbonate materials, the impervious clay beds that predominate in

the area, and the alleged self-sealing aspects of the gypsum stacks, the concensus appears to be that impacts will be highly localized. However, there are insufficient data with which to quantify effectively the potential impacts due to seepage and/or collapse.

b) Soils

The six proposed process modifications for new sources are not expected to impact the area's soils.

c) Exposure

Relative to exposure as defined, no impacts are recognized from the proposed process modifications.

d) Topography

The process modification dealing with the elimination of slime ponds will have a significant localized effect on topography. Current slime ponds, when reclaimed using conventional natural dewatering techniques, result in a final topographic surface that is considerably different in both contour and elevation from that existing prior to mining; generally, the final surface is flat-lying and elevated over the original surface. Applying the sand/clay slime mix technique to eliminate slime ponds will result in a final surface that closely approximates the original surface in both contour and elevation. However, because of the relatively small area involved in slime ponds relative to the total study area, the topographical impact of implementing this process modification would approximate "0." Locally, impacts of such a change in clay-slime disposal methods would be significant.

e) Background Radiation

None of the proposed new processing is expected to affect background radiation significantly. One highly localized area of change in

background radiation levels as a result of new process implementation is expected to be at the uranium recovery plants (modules), but the levels would be well within guidelines for radiation workers and, with the implementation of prudent protection measures, could be well within guidelines established for the general population.

Another area in which changes in background radiation levels could occur as a result of process modifications would be associated with replacing dry-rock grinding with wet-rock grinding and eliminating dryers. This would lower fugitive dust levels, thus lowering escaping radionuclides, and lower background radiation levels in the immediate vicinity of the grinders and the eliminated dryers. However, radiation dose projection resulting from current drying and grinding operations involving dry rock has been shown to be negligible for the general population and measurable but small for phosphate workers (Partridge et al 1977).

2) Biological

Process modifications included in this scenario will not significantly change the impact on terrestrial biota. Since the effects of emissions, including those from the rock-drying process and chemical manufacturing, are largely unknown or, if known, are unmeasured, minimal impact values have been assigned to the appropriate technological demand elements. The minimal impacts associated with product drying and waste placement could become negligible when rock drying is minimized and fluoride emissions from gyp ponds are reduced. Minimizing rock drying may eliminate or reduce possible fluoride uptake by nearby flora in the new mining area particularly. Reducing fluoride emissions from gyp ponds may slow fluoride's rate of accumulation in susceptible flora near the processing plants.

Minimal impact has been assigned also to slime placement, since the ponds temporarily support a variety of wildlife and terrestrial habitat eventually will develop or be reclaimed in the slime areas. Even now, the time lag in developing terrestrial habitat can be reduced by using the

flocculation method of dewatering, but whether this or the proposed sand-clay method is advantageous from the standpoint of terrestrial biota is questionable. Neither the present, fairly immediate use (within approximately 6 years after final deposition of slime) of the land for light agriculture nor the more immediate availability (within 2 years after deposition) of the land for similar purposes in the future is preferable from the standpoint of wildlife production to natural revegetation. Several abandoned slime areas are now used as wildlife sanctuaries. Additionally, eliminating the relief of the slime-pond embankments is not necessarily advantageous inasmuch as vegetational zonation associated with the slopes is more desirable for terrestrial biota - although the more level topography may be aesthetically pleasing to the Florida resident unaccustomed to hills. However, naturally revegetated slime areas that have been partially leveled and shaped would still be more desirable than pasture reclamation for wildlife.

c. Water

1) Water Quantity

Since operations under this scenario are considered to be applicable to those under Scenario 2.11 (not permitted as of 1 August 1976), the primary element for evaluation would be water consumption. The water conserved by eliminating slime ponds is extremely difficult to quantify: the clay-to-sand ratios change as the industry moves south, and the use of a conveyor for moving matrix from the mine to the beneficiation plants is not a pure water-conservation technique. In addition, it is assumed that the water conserved by these techniques would be used by additional water requirements to recover uranium. Thus, the conclusion from this rationale is that the effects resulting from this scenario will be similar to those of Scenario 2.11. Therefore, the reader is referred to Section 2, subsections B and C, for effects assessments.

2) Water Quality

Effects on water quality under the conditions of this scenario will possibly be significantly different from those under the "Without Action" alternative in terms of the technological demand elements of slime

placement, processing water use/recycle in regard to fluoride effluents, and processing waste placement in regard to radiation from gyp stacks.

a) Slime Placement

The elimination of slime ponds above surface for the mines that are considered new sources would eliminate the additional concern under Scenario 2.11 in regard to slime-pond dike breaks. Therefore, in relation to the "Without Action" alternative, the effect of this modification in regard to surface-water pollution would be "0." Placing slime below ground might tend to cause some local degradation of the water-table aquifer, but this is considered to be barely significant (-1) over the long term since this method of slime retention is not feasible in the short term.

b) Processing Water Use/Recycle

Since the New Source Performance Standards do not allow surface-water discharges, incorporating fluoride recovery methods that would reduce the fluoride contained in new-source process wastewaters would have no effect on surface-water quality; however, there would be a reduction in the fluoride loadings that would be injected into the Floridan aquifer. This reduction's effect is thought to be barely significant (+1) relative to the Floridan aquifer contamination from injection of process wastewater under the "Without Action" alternative. Therefore, the matrix entry for the effect on Florida aquifer water quality is +1.

c) Processing Waste Placement

Recovery of uranium from phosphoric acid production would reduce the potential threat of radiation contamination associated with the gyp stack, thus reducing the concern over radiation. Since data on radiation contamination from gyp stacks indicated that no contamination is occurring, a barely significant (+1) effect, which is actually in regard to the potential for contamination, is entered on the matrix.

3) Biological

Effects of phosphate industry activities on regional aquatic biota under Scenario 2.12 are expected to be essentially the same as those described previously for Scenario 2.11. The elimination of slime ponds would tremendously benefit local aquatic biota, but, according to all indications, this is not technically achievable for application to all operations during the 1977-2000 period and thus was not considered as a process modification for new sources in this evaluation.

2. Man-Made Environment

a. Land Use

Two changes brought about by the conditions of this scenario will alter the impacts of phosphate mining on land from that outlined for the "Permit Existing and New Sources" scenario (2.11). (See Section 3, subsection B.2.a. for a complete description.) Those changes are the elimination of slime ponds and the lining of gyp ponds.

Elimination of slime ponds will not actually increase the amount of reclaimed land but will make land available for other uses more rapidly than at present. Since slime ponds occupy a major portion of areas that have been mined (TI 1977a), acres of improved pasture will be available for agricultural use sooner than would occur under Scenario 2.11. Although the use of reclaimed land for pasture is viewed as less than an optimal situation (see Section 3, subsection B.2.a), the acceleration of slime-pond reclamation merits a positive (+3) impact on agricultural land use over the long term (the year 2000).

The acceleration of slime-pond reclamation will have a negative impact on land-based recreation (-1, -3), since slower revegetation of slime ponds provides habitat for hunted species.

Lining gyp ponds will reduce the impact by minimizing (0,0) the hazard of potential pollution of groundwater. The potential hazard would be applicable to urban and agricultural land use (further discussed in TI 1977e).

b. Archeological, Cultural, Historical, and Recreational

There are no changes from impacts discussed under subsection B.2.b of Section 3 ("Permit Existing and New Sources" scenario).

c. Demography, Economics, and Cultural Resources

Scenario 2.12 is not expected to alter the phosphate industry effects previously discussed for Scenarios 2.15 and 2.11.

d. Resource Use

1) Elimination of Slime Ponds

Of the two lines of strategy for eliminating slime ponds under this scenario - i.e., through process changes and through changes in reclamation procedures - impact assessments are focused on the latter (described in subsection A). Clay slimes from washer plants contain phosphate ranging from a low of about 10 percent BPL (bone phosphate of lime) to a high of about 32 percent BPL, which at present is not recovered (see Table 4.1), Also, clean, uniform-sized sands from the flotation plant accumulate. Both materials technically qualify as resources, although the local market for the sand is virtually nonexistent and the technology for recovering the phosphate has yet to be proved practical. The predominant current disposal practice results in separate storage for these two materials, an act that would facilitate future recovery if technology/cost aspects of production and/or market benefits justified such recovery. The sand/clay mix process modification under Scenario 2.12 would reduce the "availability" of these materials, severely complicating eventual recovery.

It is estimated that up to 24,000 hectares (nearly 60,000 acres) of slime ponds and up to 6,500 hectares (about 16,000 acres) of land containing the predominantly clean sand tailings currently exist as potential resources in the study area as a result of current and past phosphate mining and beneficiation activities. For effects assessment, however, these are considered to be tertiary resources. Furthermore, it is not anticipated

that any significant recovery of phosphate values contained in the slime ponds will be effected during the period through 2000 because of the availability of sufficient reserves of minable rock in the area or that there will be any significant market for the waste sand. Also, the potential elimination of these materials from secondary recovery by the implementation of the sand/clay slime mix technique for land reclamation appears to be significantly offset by the elimination of slime ponds per se as a potential environmental detriment. Thus, the impact of eliminating these tertiary resources is "0" over both the near and long terms.

Table 4.1. Study Area Phosphate Balance Sheet: Proportions of Recovered and Waste Products*

Percent BPL† in Matrix, Recovered Products, or Waste	Gross Wt [metric (short) tons]		BPL Contents [metric (short) tons]		BPL Contents (% of total)
Phosphate matrix (36%)	90.72	(100.00)	32.7	(36.0)	100.0
Coarse pebble (72.0%)	1.68	(1.85)	1.2	(1.3)	3.7
Medium pebble (72.0%)	2.99	(3.30)	2.2	(2.4)	6.6
Fine pebble (72.2%)	3.27	(3.60)	2.4	(2.6)	7.2
Total pebble (72.2%)	7.94	(8.75)	5.7	(6.3)	17.5
Coarse flotation (75.0%)	5.35	(5.90)	4.0	(4.4)	12.2
Fine flotation (76.0%)	13.61	(15.00)	10.3	(11.4)	31.7
Total flotation (75.8%)	18.96	(20.90)	14.3	(15.8)	43.9
Waste tailings‡ (9.0%)	33.24	(36.65)	3.0	(3.2)	9.0
Slimes, plus 200 mesh (27.4%)	9.98	(11.00)	2.7	(3.0)	8.4
Slimes, minus 200 mesh (34.8%)	20.59	(22.70)	7.2	(7.9)	21.9
Total slimes (32.4%)	30.57	(33.70)	9.9	(10.9)	30.3
Grand total	90.70	(100.00)	33.0	(36.2)	100.7

* U.S. Bureau of Mines 1975.
† BPL = bone phosphate of lime or tricalcium phosphate [$Ca_3(PO_4)_2$].
‡ Tailings from flotation treatment.

2) Uranium Recovery

It has been estimted the 12 phosphoric acid plants in the study area pass 4.57×10^6 pounds (2.07×10^6 kilograms) of U_3O_8 per year. Assuming constant throughput for the plants, the amount of uranium available for recovery will be on the order of 41.1×10^6 pounds (18.7×10^6 kilograms)

from 1977 through 1985 and 109.7 x 10^6 pounds (49.9 x 10^6 kilograms) from 1977 through 2000. Assuming a constant price of $40 and a recovery cost of $15 per pound, the rank benefit of recovery would approximate $1.03 billion for 1977-85 and $2.74 billion for 1977-2000.

Implementation of this process modification will not affect the uranium resources of the area; the bulk of the mineral extracted during mining, along with the phosphate, leaves the area through phosphate products shipped. Therefore, no effects are noted on the matrix for this element (mineral resources). The effects and impacts of implementing full-scale uranium recovery will center on economic values.

3) Fluoride Recovery

Since reported costs of recovery exceed the prices by 25-36 percent, fluorides are not considered to be a viable mineral resource of the area.

C. SUMMARY OF PRIMARY EFFECTS

1. Natural Environment

a. Atmosphere

Of the proposed process changes, only wet-rock processing will affect air quality - but it will have little effect on the pollutant load in the study area outside of Polk County, site of most of the existing drying capacity. However, air quality is not expected to improve because of offsetting utility emissions.

General remarks about inventory projections appeared earlier. This scenario affects emissions under the drying category and fertilizer production (grinding). The changes will be negligible other than in Polk County where existing activity is concentrated. The emission projections are summarized in Table 4.2.

Table 4.2. Summary of Projected Emissions under Scenario 2.12

County	Category	Demand Element	Metric Tons per Year TSP 1976	TSP 1985	TSP 2000	SO_2 1976	SO_2 1985	SO_2 2000
Charlotte	Area sources	–	1,862	2,953	4,961	147	234	392
	Point sources							
	Miscellaneous							
	Noncitrus	–	32	51	85	40	64	106
Total			1,894	3,004	5,046	187	298	498
DeSoto	Area sources	–	1,656	2,303	3,179	67	94	129
	Point sources							
	Miscellaneous							
	Citrus	–	29	29	29	85	85	85
	Utilities	–	0	0	4,678	0	0	185,305
	Phosphate							
	Mining/clearing	4	0	4	8	0	0	0
	Storage/transport	12	0	0	0	0	0	0
	Drying	13	0	0	0	0	0	0
Total			1,685	1,689	7,894	152	179	185,519
Hardee	Area sources	–	2,572	3,443	4,831	73	97	137
	Point sources							
	Miscellaneous							
	Noncitrus	–	23	30	43	5	6	8
	Citrus	–	15	15	15	109	109	109
	Phosphate							
	Mining/clearing	4	0	13	29	0	0	0
	Storage/transport	12	0	0	0	0	0	0
	Drying	13	0	0	0	0	0	0
Total			2,610	3,501	4,918	187	212	254
Hillsborough	Area sources	–	12,865	15,498	18,578	2,695	3,246	3,892
	Point sources							
	Miscellaneous							
	Noncitrus	–	1,815	2,186	2,620	7,539	9,083	10,887
	Citrus	–	2	2	2	16	16	16
	Utilities	–	3,831	6,816	7,835	213,218	222,932	233,645
	Phosphate							
	Mining/clearing	4	5	12	10	0	0	0
	Storage/transport	12	1,636	1,636	1,636	0	0	0
	Drying	13	87	0	0	307	0	0
	H_2SO_4	17	0	0	0	15,946	5,153	5,153
	Fertilizer	18	348	334	334	595	595	595
	Animal feed	19	104	104	104	1,029	1,029	1,029
Total			20,693	26,588	31,119	241,345	242,054	255,217
Manatee	Area sources	–	3,121	4,242	5,814	348	474	648
	Point sources							
	Miscellaneous							
	Noncitrus	–	132	179	245	118	161	220
	Citrus	–	164	164	164	0	0	0
	Utilities	–	276	2,211	2,211	3,801	30,407	30,407
	Phosphate							
	Mining/clearing	4	0	14	16	0	0	0
	Storage/transport	12	11	19	19	0	0	0
	Drying	13	0	0	0	0	0	0
	H_2SO_4	17	0	0	0	1,648	276	276
	Fertilizer	18	32	39	39	24	28	28
Total			3,736	6,868	8,508	5,939	31,346	31,579
Polk	Area sources	–	11,199	14,133	18,452	901	1,137	1,485
	Point sources							
	Miscellaneous							
	Noncitrus	–	586	740	966	318	402	525
	Citrus	–	436	436	436	625	625	625
	Utilities	–	295	965	965	6,987	13,695	13,695
	Phosphate							
	Mining/clearing	4	68	66	13	0	0	0
	Storage/transport	12	4,447	4,447	4,447	0	0	0
	Drying	13	1,178	0	0	7,581	0	0
	H_2SO_4	17	0	0	0	27,699	16,129	16,129
	Fertilizer	18	543	543	543	1,632	1,632	1,632
	Animal feed	19	106	106	106	40	40	40
	Elemental phosphorus	20	335	335	335	832	832	832
Total			19,193	21,771	26,263	46,615	34,492	34,963
Sarasota	Area sources	–	2,901	4,100	5,871	349	494	706
	Point sources							
	Miscellaneous							
	Noncitrus	–	114	162	232	175	246	354
Total			3,015	4,262	6,103	524	740	1,060

b. Land

1) Physical

a) Unique Physical Features

Of the new process modifications considered under this scenario, only one is significant relative to the unique physical features of the area: the elimination of aboveground slime-storage impoundments. Where conventional impoundments result in dams up to 12.2 meters (40 feet) abovegrade, modification No. 1 (elimination of slime ponds) will result in containment dikes of only about 1 meter (3.3 feet) abovegrade. It is anticipated that this reduction of abovegrade loading will effectively reduce the risk of slime-pond collapse into underlying karst features.

b) Soils

The proposed process modifications are not expected to have any significant effect on the soils of the area except for the fact that the principal technique for slime-pond elimination will accelerate the date on which slime areas will become available for the start of natural soil development processes. It is estimated that instituting this process modification under Scenario 2.11 will "make available" an additional 4,047 hectares (10,000 acres) by 1985 and an additional 2,792 hectares (6,900 acres) by 2000; under Scenario 2.11', the estimates are 4,047 hectares (10,000 acres) and 6,556 hectares (16,200 acres) respectively. The impact of making these soils available at an earlier date cannot be accurately assessed because soil quality relative to the eventual production of truck crops or citrus (the criteria for assessing impacts on soils of the area) cannot be forecast. However, because of the relatively small number of acres involved, the impact is expected to be insignificant.

c) Exposure

The process modifications of this scenario will impart no impact relative to exposure of the geologic section.

d) Topography

Eliminating slime ponds through the sand/slime mix technique will result in a topographic surface approximating the original surface over one-half of the mine area; the overall elevation will be only slightly higher and generally will be flatter than the original surface. Final contouring of the slime/sand mix area will depend on the specifics of the reclamation plan for each area, which will dictate both average elevation and local slope.

e) Background Radiation

(i) Elimination of Slime Ponds

Slime disposition using the sand/clay mix technology is not expected to result in a final surface that is significantly different in radionuclide content from that in conventional slime ponds; primarily, both techniques require final top dressing with sand and overburden in the final configuration. There may be slight differences in background radiation during slime fill and cover operations using the sand/clay mix technique, but the impact of such an increase will be insignificant. Specific background radiation data with respect to the mix technique have not been collected.

(ii) Uranium Recovery

Uranium recovery will not appreciably alter background radiation levels in the study area. Radionuclides recovered by this process modification reduce radioactivity concentrations in phosphate products, which are shipped out of the area. Waste products, which generally remain in the area, are not expected to show a decline in radionuclide concentration. Background radiation levels may increase slightly in the immediate vicinity of the uranium recovery modules, but these increases will not be significant. However, the operation of each module will have to be in accordance with occupational and health safety regulations for radiation workers.

(iii) Wet-Rock Grinding

Eliminating dryers and dry grinders through the implementation of this process modification is expected to reduce airborne radionuclide concentrations in the immediate vicinity of the replaced process equipment. The impact of such a change on exposure to phosphate workers and the general population is expected to be "0," since current processes result in "0" (unmeasurable) impacts; i.e., dose projections for phosphate workers have been shown to be small and well within guidelines.

f) Noise

Any increases in noise levels as a result of implementing the new process modifications listed for this scenario will have no effect on the general population of the area, and any potential impact on phosphate workers will be readily controllable through the use of restricted access to noisy areas or through personal noise-protection devices. Noise levels within facilities required for the listed process modifications are expected to be within occupational and health safety regulations for workers.

2) Biological

The reader is asked to refer to the corresponding discussion in subsection B of this section.

c. Water

1) Water Quantity

The reader is referred to Section 2, subsection C.

2) Water Quality

a) Radiological

The sand/clay mix technology applied to the elimination of slime ponds is not expected to have an appreciable impact on the background radiation (radionuclide concentration in ground waters). A favorable impact

using the technology exists for surface waters, since it eliminates the conventional slime impoundment; potential for a disastrous break and slime spill (with the attendent increase in radionuclide concentration, particularly radium-226). Current practices applied to construction, maintenance, and inspection of these dams have reduced the failure potential significantly in the last 10 years, but no model exists to quantitatively express this reduction.

Lining gypsum stacks and cooling-water ponds at the chemical processing plants is expected to protect ground water from radionuclide contamination, but insufficient data exist to quantify seepage from established gypsum stcks and cooling-water ponds. Thus, there can be no projections of the impact of establishing impervious membrane linings for new ponds, but it can be said that the potential for adverse localized impacts would be significantly reduced if practical lining methods were developed.

b) Other Water Quality Parameters

The primary effects of this scenario are:

- Concern regarding contamination of the water-table aquifer by directly exposing the water table to the slime material
- Less concern about slime-pond breaks contaminating surface-water systems than under Scenario 2.11 but equal concern about slime-pond breaks relative to the "Without Action" alternative since only "new sources" are to incorporate the modification
- A reduction in the potential for contaminating the Floridan aquifer through the injection of chemical processing wastewaters

3) Biological

Effects of phosphate industry activities on regional aquatic biota under Scenario 2.12 are expected to be essentially the same as those described previously for Scenario 2.11. The elimination of slime ponds would represent a tremendous benefit to local aquatic biota, but, according to all

indications, this is not technically achievable during the 1977-2000 period and thus was not considered as a process modification for new sources in this evaluation.

2. Man-Made Environment

a. Land Use

The reader is asked to refer to the discussion under subsection B of this section.

b. Archeological, Cultural, Historical, and Recreational

The reader is asked to refer to the discussion under subsection B of this section.

c. Demography, Economics, and Cultural Resources

Scenario 2.12 is not expected to alter the phosphate industry effects previously discussed for Scenarios 2.15 and 2.11.

d. Resource Use

1) Elimination of Slime Ponds

Elimination of slime ponds with the sand/clay slime mix technique of reclamation will effect secondary recovery of sand and phosphate in the clay by significantly complicating anticipated secondary-recovery mining techniques. However, the impact on mineral resources of the area by making secondary recovery improbable is considered insignificant.

2) Uranium Recovery

Implementation of uranium recovery processes will not impact the area's uranium resources. (The reader is asked to refer to the mineral resources discussion in subsection B.)

3) Fluoride Recovery

Since reported costs of recovery operations exceed prices by 25-36 percent, fluorides have not been considered to be a viable mineral resource of the area.

D. SUMMARY OF SECONDARY EFFECTS

1. Natural Environment

a. Atmosphere

No secondary effects were quantified in this category.

b. Land

1) Physical and Chemical

For the process modifications listed, no secondary effects of significance have been identified relative to the physical environmental demand elements of the area. The reader is asked to refer to corresponding discussions in Sections 2 and 3.

2) Biological

The reader is asked to refer to the discussion on secondary effects under Scenario 2.15 (Section 2).

c. Water

1) Water Quantity

The reader is referred to Section 2, subsection C.

2) Water Quality

The secondary effect under this scenario will be reduction in gyp piles' potential for radiation contamination of surface waters and the water-table aquifer and Floridan aquifer systems.

3) Biological

Secondary effects of phosphate industry activities for this scenario will be the same as those described for Scenario 2.15.

2. Man-Made Environment

a. Land Use

The reader is asked to refer to the discussion in subsection B of this section.

b. Archeological, Cultural, Historical, and Recreational

The reader is asked to refer to the discussion in subsection B of this section.

c. Demography, Economics, and Cultural Resources

There is no significant change from Section 3, so the reader to asked to refer to that section.

d. Resource Use

The reader is asked to refer to the corresponding discussion in Sections 2 and 3.

SECTION 5
REQUIRE REDUCED WATER USAGES

A. DESCRIPTION OF ALTERNATIVE

This scenario investigates the consequences of reduced water usage by the phosphate mining and chemical processing industries in central Florida. Existing and proposed mines and plants are as described by the conditions and limitations established in Scenario 2.11.

For existing facilities, water usage is to be reduced through the complete recirculation of all cooling and process water and containment of up to a 10-year, 24-hour rainfall with no discharge. Discharges would be allowed for conditions exceeding the 10-year, 24-hour rainfall or equivalent but would have to meet best practical technology (BPT) standards. Similar constraints are to be imposed on new facilities, except that a 25-year, 24-hour rainfall will be substituted for the 10-year, 24-hour storm.

In examining water usage by the phosphate industry under the conditions of this scenario, effluent discharge rates for both mining operations and chemical processing are significant. Mines vary in size, rate of production, and mining techniques. Most employ draglines, but dredges are also utilized for matrix extraction. For transporting the ore from pit to wash plant, a conveyor belt system is being tried at one location as an alternative to the conventional matrix slurry pipeline, resulting in a decrease in [water use]* and electric power consumption (Hoppe 1976). Similarly, the chemical processing plants manufacture the many phosphorous-related products in varying quantities and at different production rates. These variations between mines and plants make it impractical to determine the amount of effluent discharged at individual sites. This scenario, then, considers only the effects of the containment of rainfall as described earlier. Since effluent discharge rates are not included, the rainfall projections apply

*An opinion not shared by Mr. Timberlake of Brewster Phosphate

equally to either mining or chemical processing. Storage capacities determined for rainfall containment would require enlargement to include the effluents discharged at a given mine or plant. Facilities are grouped on the basis of existing or new source classifications as designated by the NPDES permits.

To determine the net result of rainfall containment, only precipitation and evaporation are taken into account; it is assumed that the rainwater will be retained in impoundments similar to the settling ponds currently in use and that seepage through dikes or into the pond floor will be negligible and thus can be ignored. According to the Climatic Atlas of the United States published by the Department of Commerce (USDC 1968), the mean annual Class-A pan evaporation rate through the study area is 65 inches; the same source shows the mean annual lake evaportion for the study area to be 50-52 inches with a mean annual Class-A pan coefficient of + 77 percent relating the lake evaporation rate to the pan evaporation rate. Average monthly rainfall data for six locations - three on the interior and three on the perimeter of the study area - have been tabulated to yield average monthly rainfall applicable across the entire study area; based on U.S. Weather Service records from 1931 to 1960 (USDC 1965), it is 53.24 inches (Figure 1.4).

In terms of average rainfall vs evaportion, 3 years have been evaluated - an average year; an average year with a 10-year, 24-hour storm; and an average year plus a 25-year, 24-hour storm. Figure 1.5 shows the net rainfall vs the evaporation from the rainfall for each month. By the end of an average year, a net surplus of 0.41 inches of water from rainfall has been accumulated. The net curve for a year in which a 10-year, 24-hour storm occurs during the month of heaviest rainfall is presented in Figure 1.6. This curve results in a net surplus of 8.29 inches at the end of the year and includes the 0.41-inch surplus from the previous year. The net curve for a year in which a 25-year, 24-hour storm occurs during the month of heaviest rainfall is presented in Figure 1.7. The year-end surplus of 10.04 inches includes the 0.41 inch remaining from the previous year. To comply with the conditions imposed by this scenario, an existing facility (mine or

plant) would require a storage capacity capable of retaining 0.41 inch of rainfall cumulatively for each year of the facility's estimated life plus 8.29 inches for the year in which the 10-year, 24-hour rainfall occurred. A new facility would require a capacity of 0.41 inch per year of life plus 10.04 inches for the year of the 25-year, 24-hour rainfall.

The magnitude of the storage capacities can be illustrated by considering a hypothetical water impoundment with a surface area of 1000 acres. The average-year surplus of 0.41 inch on a 1000-acre pond would equate to a constant inflow of 21.18 gallons per minute if discharged over a 1-year period. Similarly, the 8.29-inch surplus for the year of the 10-year, 24-hour rainfall converts to a constant discharge of 428.3 gallons per minute over a year's time. For new facilities, a 1000-acre pond would require a constant outflow of 518.7 gallons per minute to dissipate the 10.04-inch surplus following a 25-year, 24-hour rainfall.

In summary, the new effect of the conditions imposed for this scenario would be the creation of impoundments for retaining the annual surplus of rainfall. The capacity of such impoundments would be determined by the life of the facility and the quantity of effluent discharged as a result of the facility's operations. Rainfall accumulated in the storage ponds could be made available for use in mining or processing, thereby reducing the groundwater withdrawal requirement.

B. MATRIX AND SUPPORTING RATIONALE

1. Natural Environment

a. Atmosphere

The reader is referred to the discussion under this subhead in Section 3.

b. Land

1) Physical and Chemical

Requiring reduced water usage is not expected to impart any measurable impacts on unique physical features, soils, exposure, topography, background radiation, and noise.

2) Biological

Additional standing-water bodies created by captured rainwater would displace terrestrial habitat. The effects on terrestrial biota would be similar to those associated with mining pits (see Sections 2 and 3). Since no estimate of areal extent of the necessary containments is given, impact cannot be judged. Apparently, the extent will be minimal compared with that of mining pits. Reduced usage of groundwater (the result of using the impounded rainwater) will have no effect on terrestrial biota. Any groundwater changes that may affect terrestrial biota will occur during mining into the shallow aquifer.

c. Water

1) Water Quantity

This scenario investigates the consequences of reduced water usage by the phosphate industry under the conditions and limitations defined in the subsection A of this section. A serious burden is placed on the surface-water regime. Additional acres will be required for the defined containments, which will result in reduced runoff required for surface flows. If ones assumes that the containments will be constructed along drainage patterns, then surface flows will be drastically affected since discharges will be allowed only for conditions exceeding the 10- and 25-year 24-hour rainfall. It is difficult to conceive that containments could be designed to discount completely a makeup requirement, so it is assumed that makeup from the Floridan aquifer would be required. Reduced water consumption demands for the entire industry can be assumed under these constraints, but this would be absolutely meaningless since effect assessment could not be determined from such a figure. Required to evaluate the reduced water

consumption data would be utilization of the USGS digital water model. Using this technique, drawdowns could be determined for each facility relative to the 1975 potentiometric surface and simulated potentiometric surface maps could be developed such that the temporal and spatial stresses on the Floridan aquifer could be assessed (relative only to the phosphate industry). Since these variables are currently unknown, a quantitative assessment for this scenario cannot be made. Thus, for the purpose of this report, a qualitative approach will be used, comparing this scenario with Scenarios 2.11 and 2.15. The figures in 2.11 are considered applicable for this scenario.

2) Water Quality

The conditions of this scenario relate entirely to discharges from mining and chemical processing facilities. The scenario poses an additional consideration: since rainfall accumulated in storage ponds could be used in mining or processing, a reduction in groundwater withdrawal is indicated.

In relation to water quality, the impounding of the 10-year 24-hour rainfall event and the 25-year 24-hour rainfall event would (1) greatly increase the amount of surface water impounded within the study area, (2) increase loss of water by evaporation, and (3) decrease recharge to the water-table aquifer and runoff to streams, both of which would decrease the base flow to streams. The reduction of flow in the streams would tend to allow creation of greater concentrations of nutrients in the streams by pollutional loads from other sources (e.g., agricultural runoff). Containment of phosphate mining and processing wastewaters would tend to concentrate the wastewater constituents and potentially create eutrophic conditions within the impoundments. Also, decreased base flow to streams, with accompanying decreased nutrient loadings entering the streams and flowing into the estuaries and harbors, might result in "no flow" in many of the streams in the study area for an extended period each year; many segments would become dry, and the estuaries and harbors would become less productive. Thus, on the scale of barely significant (± 1), moderate (± 5), highly significant (± 7), and severe (± 10), the impounding's effect on the water quality of the region will be highly significant (-7).

3) Biological

Reduced water usage by the phosphate industry will have little effect on aquatic biota as described earlier for Scenario 2.11, because the vast majority of water used by the phosphate industry is ground water. The additional containment requirement for new sources (25-year 24-hour maximum rainfall event) will represent potential for increased standing surface-water resource, although it is unlikely that these impoundments will be filled. In any event, they represent only a small proportionate increase in standing-water habitat for the study area.

2. Man-Made Environment

a. Land Use

There are no changes in the impacts noted under the "Permit Existing and New Sources" scenarios (Section 3, subsection B.2.a) for any land use category.

b. Archeological, Cultural, Historical, and Recreational

There are no changes in the impacts noted under the "Permit Existing and New Sources" scenarios (Section 3, subsection B.2.b).

c. Demography, Economics, and Cultural Resources

There is no significant change from the effects discussed in Section 3, so it is suggested that the reader refer to that section.

d. Resource Use

Requiring reduced water usage is not expected to impart any measurable impacts on resource usage. (Water is not listed as a resource for this discussion.)

C. SUMMARY OF PRIMARY EFFECTS

1. Natural Environment

a. Atmosphere

The reader is referred to the discussion under this subhead in Section 3.

b. Land and Wetlands

1) Physical

Reduced water usage is not expected to have any measurable effects on the physical environmental demand elements of the area. The reader is asked to refer to corresponding discussions in Sections 2, 3, and 4.

2) Biological

The reader is asked to refer to subsection B of this section.

c. Water

1) Water Quantity

This scenario evaluating the mining and beneficiation operations utilizing recirculated water assumes that makeup water will be pumped from the Floridan aquifer. The only source of water for the containments will be rainfall falling onto the areas being mined. This, then, is a surface-water problem although it indirectly reflects on the groundwater system of the Floridan aquifer and the water-table aquifer. In many instances, current pumpage from the Floridan aquifer for mining purposes can be considered an augmentation of surface-water flows. Prime examples of such augmentation of surface-water flows by drainage of excess groundwater pumpage from the Floridan aquifer are the Alafia and Peace rivers. Although there has been neither a clear-cut definition of the groundwater contribution to those river systems nor quantification of the contribution, the phenomenon has been observed.

As mentioned previously, the conditions of this scenario will be very beneficial to the Floridan aquifer in that the reduction in pumpage will raise the potentiometric surface of the Floridan aquifer. At the same time, however, the reduction in pumpage can be considered to be a reduction in overall water input to the water-table aquifer; as less water reaches the water-table aquifer, less water will emerge as surface-water runoff. Thus, one can conclude that this scenario will have an effect on flows in rivers presently draining mining areas - primarily the Alafia, Little Manatee, Manatee, and Peace rivers. If surface-water flows in those areas are reduced, the effects will certainly be felt by aquatic flora and fauna that depend on the flows of those rivers.

2) Water Quality

a) Radiological

Requiring that water usage by the phosphate industry be reduced is not expected to materially effect the radionuclide concentrations of surface waters or ground waters. The reader is asked to refer to corresponding discussions in Sections 2 and 3.

b) Other Water Quality Parameters

The reader is referred to the discussion under subsection B of this section.

3) Biological

Reducing phosphate industries' water usage will have little effect on aquatic biota as described earlier for Scenario 2.11, because the vast majority of water used by the phosphate industry is ground water. The additional containment requirement for new sources (25-year 24-hour maximum rainfall event) will represent potential for increased standing surface-water resource, although it is unlikely that these impoundments will be filled. In any event, they represent only a small proportionate increase in standing-water habitat for the study area.

2. Man-Made Environment

a. Land Use

There are no changes in the impacts noted under the "Permit Existing and New Sources" scenario (Section 3, subsection B.2.a) for any land use category.

b. Archeological, Cultural, Historical, and Recreational

There are no changes in the impacts noted under the "Permit Existing and New Sources" scenario (Section 3, subsection B.2.b).

c. Demography, Economics, and Cultural Resources

There is no significant change from the effects described in Section 3, so the reader is asked to refer to that section.

d. Resource Use

Reduced water usage is expected to have no effect on the physical resources of the area except on water itself which is discussed in subsection C.1). It is also suggested that the reader refer to corresponding discussions of resources in Sections 2 and 3.

D. SUMMARY OF SECONDARY EFFECTS

1. Natural Environment

a. Atmosphere

The reader is referred to the discussion under this subhead in Section 3.

b. Land

1) Physical

Reduced water usage is not expected to effect the physical environmental demand elements of the area. The reader is asked to refer to corresponding discussions in Sections 2 and 3.

2) Biological

The reader is asked to refer to subsection B of this section.

c. Water

1) Water Quantity

Reduction in pumpage will raise the potentiometric surface of the Floridan aquifer, which will directly reduce pumping cost. This broad, general assessment is meaningless, however, without absolute data for reference.

2) Water Quality

The reader is referred to the discussion in subsection B of this section.

3) Biological

The phosphate industry's reduced use of water will have little effect on aquatic biota as described earlier for Scenario 2.11, because the vast majority of water used by the phosphate industry is ground water. The additional containment requirement for new sources (25-year 24-hour maximum rainfall event) will represent potential for increased standing surface-water resource, although it is unlikely that these impoundments will be filled. In any event, they represent only a small proportionate increase in standing-water habitat for the study area.

2. Man-Made Environment

a. Land Use

There are no changes in the impacts noted under the "Permit Existing and New Sources" scenario (Section B, subsection B.2.a) for any land use category.

b. Archeological, Cultural, Historical, and Recreational

There are no changes in the impacts noted under the "Permit Existing and New Sources" scenario (Section B, subsection B.2.b) for any land use category.

c. Demography, Economics, and Cultural Resources

There is no significant change from Section 3, so the reader is asked to refer to that section.

d. Resource Use

Reduced water usage is not anticipated to affect the mineral resources of the area.

SECTION 6

CONTROL ACTIVITIES IN WATERS OF U.S. AND WETLANDS

A. DESCRIPTION OF ALTERNATIVE

This scenario is divided into two parts. The first would prohibit mining or development of facilities in the waters of the U.S. and wetlands as defined by the regulations promulgated pursuant to administration by the U.S. Corps of Engineers of Section 404 of the Federal Water Pollution Control Act (FWPCA) amended in 1972. The second part would allow mining or facilities development in the waters of the U.S. and wetlands but require restoration to provide at least an equivalent habitat for any species on the Important Species List for which habitat existed prior to mining.

The Corps may issue permits for the discharge of dredged or fill material into the navigable waters at specified sites. The term "navigable waters" includes: coastal waters, wetlands, mudflats, swamps, and similar areas; freshwater lakes, rivers, and streams, as well as all tributaries to these waters, that are used, were used, or are susceptible to use for transport in interstate commerce; interstate waters; certain specified intrastate waters in which pollution would affect interstate commerce; and freshwater wetlands including marshes, shallows, swamps, and similar areas that are contiguous or adjacent to the above described lakes, rivers, and streams and are periodically inundated and normally characterized by the prevalence of vegetation requiring saturated soil conditions for growth and reproduction. Headwaters (defined as the point on the stream above which flow is normally less than 5 cubic feet per second) are excluded from permit requirements unless required in the interest of water quality.

The Corps of Engineers, in conjunction with the EPA, developed a 3-phase plan for implementing its administration of Section 404. Under the groundrules set for the central Florida phosphate industry areawide impact assessment program, only Phase I would have been described; however, since the full implementation occurred on July 1, 1977, TI made an exception to

the groundrules and assessed the impact on wetlands in accordance with full implementation of the Corps of Engineers rules and regulations for administration of Section 404 of the FWPCA.

The Corps of Engineers of the Jacksonville District, which has jurisdiction over Florida for Corps matters, recently arrived at a joint review and processing of application procedures with the Florida Department of Environmental Regulation (DER). The latter requires permits for work on or in the waters of the state and, specifically relevant to this scenario, requires a permit whereby dredge and fill activities are to be conducted in submerged lands or in transitional zones of submerged lands in the state. The DER determines jurisdiction in a similar manner as that of the Corps and includes in its definitions that transitional zones are characterized by the dominance of certain plant species.

As mentioned elsewhere in this working paper, the USGS (LUDA) Land Use-Land Cover maps representing the 7-county study area were the most comprehensive in existence at the start of the central Florida phosphate industry areawide impact assessment program; however, it was known that the staff of the U.S. Fish and Wildlife Service National Wetlands Research Center at St. Petersburg was in the process of developing maps representing all available photography of wetlands of the U.S. Unfortunately, that rendering of Florida maps was not available in time for this program. Thus, the water and wetlands land use-land cover definitions and mapping categories of the USGS (LUDA) maps had to be used (Plate 1 in map pocket). (See TI 1977c: Chapter 3 for complete definitions.) For an areawide evaluation, this procedure is adequate. Site-specific actions, however, require closer scrutiny. The Corps of Engineers determines for each applicant the boundaries of jurisdiction. One recent applicant was given boundaries in Hookers Prairie that encompass approximately 50 percent more area than does the USGS (LUDA) map for the same location (Figure 1.8).

Organisms that would require restoration of at least an equivalent habitat under the second part of this scenario include species on state and

federal rare, threatened, endangered, or special concern lists; species of ecological importance; and species of significant economic benefit. Those in wetlands potentially affected by phosphate industry activities are as follows:

Southern Dusky Salamander	Short-tailed Hawk
Dwarf Salamander	Florida Sandhill Crane
Slimy Salamander	Limpkin
Bronze Frog	King Rail
Ornate Chorus Frog	Virginia Rail
American Alligator	Sora
Diamondback Terrapin	Yellow Rail
Southern Hognose Snake	American Woodcock
Scarlet Kingsnake	Yellow-billed Cuckoo
Broad-headed Skink	Pileated Woodpecker
Eastern Indigo Snake	Hairy Woodpecker
Striped Swamp Snake	White-breasted Nuthatch
Red-bellied Snake	Yellow Warbler
Smooth Earth Snake	Louisiana Waterthrush
Black-crowned Night Heron	Golden Mouse
Yellow-crowned Night Heron	Eastern Woodrat
American Bittern	Round-tailed Muskrat
King Rail	River Otter
Hairy Woodpecker	Bobcat
Wood Duck	Wild Hog
Sharp-shinned Hawk	

Those found in waters of the U.S. potentially affected by phosphate industry activities are as follows:

- Estuarine

Striped Mullet	Black Drum
Yellowfin Menhaden	Spotted Seatrout
Gulf Menhaden	Snook
Bay Anchovy	Sand Seatrout
Red Drum	Tarpon
Croaker	Southern Flounder

- Freshwater

Largemouth Bass	Redear Sunfish
Bluegill	Channel Catfish

- Both

Alligator	Suwannee Cooter
Manatee	

For more information on those species listed under waters of the U.S., see Volume V, Chapter 2 (TI 1977e); for those listed under wetlands, see Volume VI, Section 5 (TI 1977f).

There is no demonstrated feasible means for restoring wetlands, although reclamation can result in wet lands. To restore wetland habitat in order to protect and propagate all the fish, shellfish, and wildlife just listed, there would have to be management of variables required for the creation of wetlands, which some believe only occur naturally over a period of approximately 4,000 years of natural processes (American Fisheries Society 1977). Only nature can create a wetland (Fisheries, Volume 2(4):7). The relationship of present and projected phosphate industry activities to waters of the U.S. and wetlands is presented in Plate 1 (in map pocket).

As of this date, no chemical processing plants are included in industry plans. In its DRI for a Hardee County site near the Four Corners area (see Plate 1), CF Mining Corporation described a fertilizer plant, but it has since canceled its plans to build it. Thus, all potential environmental effects are limited to those resulting from mining and beneficiation operations.

B. MATRIX AND SUPPORTING RATIONALE

1. Natural Environment

a. Atmosphere

The reader is referred to the discussion under this same subhead in Section 3.

b. Land

1) Physical and Chemical

Under this scenario (2.14A), no mining or facilities development will be allowed in waters of the U.S. and wetlands as defined in Section 5,

subsection A. For Scenario 2.15, this would conceivably withdraw approximately 3,000 hectares (7,400 acres) from scheduled production during the 1977-85 time period and approximately 5,140 hectares (12,700 acres) during 1977-2000. Under Scenario 2.11, which would grant a limited number of mining permits, it is estimated that 5,000 hectares (12,300 acres) would be excluded during 1977-85 and 10,890 hectares (26,900 acres) between 1977 and 2000. For Scenario 2.11', which would permit all mine applications, an estimated 5,000 hectares (12,300 acres) and 13,800 hectares (34,100 acres) of wetlands would be excluded in the respective time periods. It is assumed, however, that such exclusions will not materially affect production tonnages previously estimated for the two time periods under Scenario 2.11; inasmuch as mining activities are expected to merely shift to lands not classified as U.S. waters or wetlands. This assumption is primarily based on the fact that sufficient reserves exist within the study area to accommodate the required shift in mining operations. Under Scenario 2.11', such is not the case (see Figure 1.1 in pocket) but would become applicable if phosphate resources rather than reserves were considered.

Accepting the preceding assumption for both scenarios (2.11 and 2.11'), one would anticipate that restricting mining in waters of the U.S. or wetlands would have no effect on unique physical features, soils, exposure, topography, background radiation, and noise. Impacts from this exclusion to mining in the area therefore, is considered insignificant relative to the environmental demand elements just listed.

2) Biological

In view of the fact that freshwater wetlands restoration has not been demonstrated seems infeasible on a large scale within a reasonable time, the only applicable part of this scenario is A, which prohibits mining or development of facilities in waters of the U.S. and wetlands. Designating wetlands as protected areas would eliminate the worst-case impact associated with mining them, and impacts on important species would be lessened. If mining of wetlands is allowed on the uncertain basis of restoring equivalent habitat for important species (part B of Scenario 2.14), the impact

assessment for terrestrial biota remains the same as described for Scenario 2.11.

The assessment associated with mining wetlands was determied, as with other habitat types, by considering the importance of the habitat and the feasibility of ts restoration (see Section 2). The worst-case assessment is consistent with other findings, including an EPA-sponsored study (Darnell 1976), which concluded that wetland habitat loss is the most important impact of construction activity.

Concern for the depletion of wetlands habitat has prompted a variety of activity including proposed legislation and legal suits to protect remaining wetlands, as well as intensive research and pilot projects to replace some that have already been destroyed. That the latter endeavors offer little assurance of large-scale success is evident in the increasing probability of wetlands protection. A recent federal court settlement in southeastern Louisiana (the only other U.S. location of expansive wetlands, besides Florida) permits construction of a highway provided that it is built with openings under the roadway large enough to prevent damage to the wetlands it transverses (Fisheries 2(4):7). In a report to the governor of Florida, the Florida Environmental Land Management Study Committee (1973) concluded that the technique most readily available to protect Florida's wetlands is the "critical areas" designation (Section 380.5(2)(a), Florida Statutes). Since the legislation sets a cap of 5 percent of the land of the state for all categories of critical areas, the recommendation was made to lift the cap to include extensive coastal and interior wetlands. The committee indicated that the legislature had already recognized the need to lift the cap in its Big Cypress legislation of 1973. At the time of the report (December 1973), the committee noted that development in the state can continue unabated until final regulations are adopted, which could well be too late to protect the valuable wetlands resource. Comprehensive regulations are yet to be set forth, although other groups including the Central Florida Regional Planning Council (1977), encourage them. In the Louisiana case, negotiations with the state broke down and final recourse was the federal court.

The most extensive pilot wetlands restoration projects are being conducted on dredged-materials sites, primarily in tidal waterways (Garbisch 1977). The projects are virtually confined to marsh establishment. Although both fresh- and saltwater marsh establishment is being tested, basic research for determining necessary conditions for vegetation survival has centered mostly on saltwater species, particularly smooth cordgrass (Spartina alterniflora). Environmental factors that affect vegetation establishment on saltwater sites are tides, salinity, drainage, aeration, water table, rainfall, soil, evaporation, temperature, other biota, water depth, light penetration, and current and wave action (Kadlec et al 1974). Water level, substrate water quality, turbidity, currents, and wave action are particularly important in freshwater areas. In establishing any marsh, the basic problems encountered are physically unsuitable substrates, nutrient deficiences, polluted sediments, excessive wind or current action, excessive turbidity, unfavorable patterns of water-level fluctuations, and unfavorable water depths.

Physically unsuitable substrate poses the most difficult problem in establishing particular wetlands vegetation (Kadlec et al 1974). Soils associated with many inland wetlands build up slower than those associated with coastal wetlands, adding to the difficulty of freshwater wetlands restoration. Both depositional soils and weathered soils form wetlands substrates. Frequency of inundation determines the rate at which depositional soils (including coastal wetland soils, riverine wetlands soils, and floodplain soils) build up; the alluvial soils of floodplains take the longest time to form. The various depositional soils take less time to build up than those formed by weathering in place (e.g., those associated with wet prairies). Most soils associated with the various inland wetlands in central Florida are included in the vaguely defined "freshwater swamp and marsh soil association." Generally, they are considered to be peaty or mucky, which in this case indicates mixtures of organic materials and sands. They are very poorly drained and have a high moisture content; most are continually waterlogged, and the predominantly sandy soils sometimes associated with wet prairies are waterlogged during part of the year and remain waterlogged to within a few inches of the surface during the growing season.

Another difficult problem in establishing functioning freshwater wetlands is creation of topography and drainage patterns that result in the periodic flushing vital to their effectiveness. Without alternating inundation and water release, the variety of wetlands types proposed to be created on mined land will be no more than wet lands, as abandoned slime ponds are. Both productivity and diversity can be affected by the water regime and substrate. The biota that establishes in the wet lands will be more typical of ponds or lakes. Creating the intricate drainage patterns of wetlands is a sufficiently difficult task. Even if these problems are ameliorated, however, it seems that little can be done about substrates that are unsuitable for establishment of various species of vegetation (Kadlec et al 1974).

If a compromise between wetlands protection (which is the only means of assuring wetlands presence) and development is a viable alternative, a categorization of wetland types based on importance is necessary. This is not easily done. As in the case of uplands communities, rarity or uniqueness certainly is a consideration. Otherwise, as suggested by the Florida Department of Natural Resources (1975), it is not the type of wetland but the environmental values present in the wetland that are of prime importance. Such determinations of usefulness call for site-specific evaluations of wetlands productivity (life-support value), potential for waste treatment, and other considerations (see Section 2 of this volume and TI 1977f: Volume VI, Section 5), as well as establishment of norms or other bases for comparison in order to eliminate arbitrariness. Although accomplishable, valid site-specific studies may prove lengthy and costs higher than benefits on the part of the developer.

Besides evaluations of productivity, etc., other criteria could be applied, including the relationship of a wetlands to other systems (DNR 1975). More value may be placed on wetlands having a relationship to adjacent uplands and downstream systems (e.g., river swamps and marshes) than on wetlands basically having only a relationship with adjacent uplands (pond swamps). Also, endangerment, vulnerability, and priority rankings assigned to various wetlands types by the Florida Department of Natural Resources and

Florida Game and Fresh Water Fish Commission (DNR 1975, Table 2) could be considered. More value may be placed on a highly endangered, highly vulnerable wetlands of first priority in the Peace, Withlacooche, and Hillsborough watershed (e.g., mixed hardwood swamp) than on a highly endangered, highly vulnerable wetlands of secondary priority in the watershed (e.g., freshwater marsh). Some of Florida's many wetlands types (e.g., bayheads) have not yet been ranked, however.

In order to apply importance criteria for regulatory purposes, wetlands must first be differentiated from other water bodies and from each other as well. Water relationships, vegetation, and soil types are among the factors that would be included in wetlands definitions. In general, a water regime that includes alternating inundation and water release of various periodicities hydrologically distinguishes wetlands from water bodies, although shallow submerged lands often are included as wetlands. As indicated previously, the national wetlands delineations and inventory currently underway within the U.S. Fish and Wildlife Service should be helpful in determining wetlands types and areal extent. It is anticipated that the wetlands inventory within the study area will be completed by mid-1978.

c. Water

1) Water Quantity

This scenario, as previously discussed under subsection A, limits all environmental effects to those resulting from mining and beneficiation operations. Most important are the wetlands themselves, since significant hydrological processes are involved. However, due to their nature, effects quantification is difficult; effects can be determined only qualitatively and only in a site-specific environment. When these assessments are applied relative to the entire 7-county study area, their meaning becomes reduced in importance. These effects are discussed under primary effects only (subsection C of this section).

b. Archeological, Cultural, Historical, and Recreational

Elimination of the mining of wetlands will reserve sites lying in wetlands. The number of sites is discussed in Section 2, subsection C.2.b.

The quality of land-based recreation (hunting) would be maintained by eliminating the mining of wetlands, since wildlife species associatd with wetlands would be more plentiful (see Section 2).

c. Demography, Economics, and Cultural Resources

There will be no significant change from the discussion in Section 3. It is suggested that the reader refer to that section.

d. Resource Use

Please refer to subsection C.2.d that follows.

C. SUMMARY OF PRIMARY EFFECTS

1. Natural Environment

a. Atmosphere

The reader is referred to the discussion of primary effects in Section 3.

b. Land

1) Physical

No impact on the physical environmental demand elements of the area are expected from the control of activities in U.S. and wetlands waters. The reader is asked to refer to subsection B.

2) Biological

The reader is referred to the discussion in subsection B of this section.

c. Water

1) Water Quantity

This scenario prohibits (part A) or limits (part B) the mining or development of facilities for beneficiation or chemical processing in waters of either the United States or wetlands. It can involve some very significant hydrological consequences. If it is assumed that permits will be issued to mine ore bodies up to the boundaries of the wetlands or set back a certain distance from them the natural system will be drastically changed.

Mining in the uplands will reduce the overall volume of earth materials by the approximate volume of marketable rock removed from the area. Although part of that void will be filled by an expanded volume of clay slimes, a net void is still expected. The net void will have serious implications if an inland-isolated wetland is involved. The wetland will most likely be located in a low-lying part of the property and possibly at the lowest elevation.

If wetlands are left undisturbed while the surrounding areas are mined, a number of steps will be required to keep the wetlands in a biologically healthy state. Because of the drainage of nearby areas associated with the mining operations, the wetland will no longer receive contributions of water from the surrounding water-table aquifer and therefore will dry up. Corrective measures to prevent this may include augmentation by pumpage from a distant surface-water body. However, if the wetland were augmented with water pumped from the Floridan aquifer, the chemical quality of the water introduced into the wetland might affect the biological health of the local biota.

If it were assumed that the wetland had not been disturbed and had been kept wet and that the mining operations were finished, reclamation would take place. It would be very difficult to reclaim the mined land surface to the previous level, however, because materials would have been removed from the area; also, the wetland that once occupied the lowest elevation in the area could become a comparatively high area. Consequently, the mining operation will have significantly altered the gradients and the

materials in the water-table aquifer. The wetland would remain temporarily as a sort of pedestal but would eventually dry up.

If the wetlands were adjacent to U.S. waters such as streams and rivers, mining activities in the basins located upstream from the wetlands could alter the hydrologic regime to some extent. The hydrologic regime would certainly be changed during the mining period and, on a long-term basis, might revert to its original state. Thus, even if wetland adjacent to water courses were not disturbed by mining operations, such operations in upstream basins could alter the flow regime of the stream and also slightly alter its chemical quality - and these two changes could have an effect on the adjacent wetland. If the wetland received water from bank storage during high flow stages of the stream, a controlled water outlet system (as is stated in mining ordinances and other regulations) would smooth out flood peaks but thereby deprive the surrounding water-table aquifer of inflows from the stream as bank storage during periods of high flow. This could alter the local hydrologic regime in the water table directly beneath the wetland.

If increases in dissolved solids in the streams were found, this might also affect the biological health of the plants whose roots tap the water table aquifer, receiving the surface water containing the higher content of dissolved solids. Although the chemical content in waters discharged from mining operations are tightly controlled by regulations (e.g., the NPDES program), levels prescribed b these rules and regulations might be higher than normally would have occurred naturally in the stream. If that were the case and the root system were sensitive to the increase of particular constituents, there could be a detrimental effect on vegetation. One substance that is very critical in this respect is boron.

As indicated in the discussion on uplands/wetlands biota and habitat quality, mining's potential and actual effects on remaining or "undisturbed" wetlands should be addressed in greater detail than now required in the DRIs.

2) Water Quality

a) Radiological

Prevention of mining in waters of the U.S. and wetlands is not expected to affect significantly the radionuclide concentration levels in the area's surface or ground waters. The shift in mining areas, however, cause slight variations in surface-water runoff patterns. In terms of radionuclide concentrations, however, the impact of such variations would be insignificant.

b) Other Water Quality Parameters

The reader is referred to the discussion in subsection B.

3) Biological

The reader is referred to the discussion in subsection B of this section.

2. Man-Made Environment

a. Land Use

The reader is asked to refer to subsection B.

b. Archeological, Cultural, Historical, and Recreational

The reader is asked to refer to subsection B.

c. Demography, Economics, and Cultural Resources

There is no significant change in primary effects from those discussed in Section 3. Therefore, the reader is referred to that section.

d. Resource Use

Restricting mining activities from waters of the U.S. and wetlands will preserve phosphate (and uranium) resources only if production lost by such restrictions is not made up by mining upland areas. Since it is assumed that potentially lost tonnage will be made up through changes in mining plans, the preservation of these resources is not expected to be affected. Forest (timber) resources discussed in corresponding paragraphs in Sections 2 and 3 do not deal with wetland forest areas but are restricted to dry-land forests; therefore, this restriction on mining and the subsequent relocation of mining may have some effect on timber resources of the area. The effect is not quantifiable because of a lack of knowledge as to the exact location of relocated mining activities.

D. SUMMARY OF SECONDARY EFFECTS

1. Natural Environment

a. Atmosphere

The reader is referred to the discussion under this same subhead in Section 3.

b. Land

1) Physical

Restriction of mining from waters of the U.S. and wetlands is not expected to impart any identifiable secondary effects on the physical environmental demand elements (unique physical features, soils, exposure, topography, background radiation, noise). The reader is referred to the corresponding discussions in Sections 2 and 3.

2) Biological

The reader is referred to subsection B.

c. Water

1) Water Quantity

The reader should refer to the subsection C discussion.

2) Water Quality

The reader should refer to the subsection C discussion.

3) Biological

The reader is referred to the discussion in subsection B.

d. Demography, Economics, and Cultural Resources

There is no significant change from Section 3, so the reader is asked to refer to that section.

2. Man-Made Environment

a. Land Use

The reader is asked to refer to subsection B.

b. Archeological, Cultural, Historical, and Recreational

The reader is asked to refer to subsection B.

c. Demography, Economics, and Cultural Resources

There is no significant change in secondary effects from those discussion in Section 3. Therefore, the reader is referred to that section.

d. Resource Use

Restricting mining activities from waters of the U.S. and wetlands is not expected to impart any secondary effects on the resources of the area. The reader is referred to corresponding discussions in Sections 2 and 3.

SECTION 7
COMPARISONS

A. INTRODUCTION

Preceding sections describe the effects and impacts of the central Florida phosphate industry as a part of the existing environment, a condition defined as the "Without Action" alternative (Scenario 2.15) and the baseline against which TI compared the four other alternatives. Also described are the effects and impacts of four alternatives to the "Without Action" alternative.

Section 1 of this volume (distributed separately) describes the process of selecting elements for inclusion in the matrix. This matrix is a model for effects assessment and is intended as a tool for technical direction. The absence of entries in a column or row of the matrix does not necessarily mean that the element represented by that column or row should have been omitted from the matrix. In assessing effects and impacts it is often as important to indicate where impacts are not likely to occur as to show where they are expected — especially when preconceptions are held by vested interests.

TI began assessing the significance of impacts by identifying effects that qualify as impacts. An effect is a change caused by interaction between environmental and technological demand elements (here, phosphate industry activities), and an impact is defined as an effect that alters the environmental system in which it occurs beyond the system's ability to buffer or compensate for the change.

Numerical significance values were assigned to each impact. Each value is based on quantitative or qualitative considerations dictated by the environmental elements involved. Values are not directly comparable among the various categories of elements. It is essential to study the rationales governing the assigning of values to fully grasp what they imply.

B. MATRIX AND SUPPORTING INFORMATION

The five scenarios or alternatives used in the study are detailed enough that desirable features may be selected from them and combined into

new alternatives. The individual matrices list specific industry activities causing the impacts. This knowledge suggests the regulatory strategy offering the highest probability of reducing or eliminating the most significant adverse impacts. After examining the summary matrix in this section, the reader is urged to review the detailed matrices and rationales in the preceding sections.

Besides the raw scores or values arrived at by TI and listed in the matrices are values reached by a numerical weighting process. These weighting factors represent priorities applied to each element by the Steering Committee and Advisory Committee to the study. By assigning these numerical values, the committees enabled TI to calculate a quantitative summary of the impact assessment effort. The matrix in the pocket shows the weighting factors and the scores representing the sums of impacts on each environmental element.

Subtotals for natural, social, and economic environmental elements were then multiplied by normalizing factors to compensate for the fact that the subtotals were based on unequal numbers of elements (41, 31, and 19 elements respectively). Table 7.1 summarizes the raw and weighted scores. Table 7.2 lists the alternatives by rank order. Scenario 2.15, the "Without Action" alternative, is absent from both tables because it represents the baseline or zero values with which the other four scenarios were compared. When the best of the four scenarios has a net negative, or adverse value, it is still only second best to 2.15.

If decision weighting factors for social and economic environmental elements had been as high as many of the weights for natural environmental elements, summary results would probably have shown net positive impacts.

Table 7.1. Environmental Impact Summary

Alternative	Natural Short Term/Long Term	Social Short Term/Long Term	Economic Short Term/Long Term	Total Short Term/Long Term
		Raw Scores		
2.11	-267/ -250	-5/ -3	29/ 176	-243/ -77
2.12	-257/ -228	-4/ -3	29/ 176	-232/ -55
2.13	-269/ -226	-5/ -3	29/ 176	-245/ -53
2.14	-249/ -206	-1/ 0	29/ 176	-221/ -30
		Decision-Weighted Scores		
		Steering Committee		
2.11	-1459/-2135	-66/-16	141/ 979	-1384/-1172
2.12	-1323/-1940	-57/-12	141/ 979	-1239/ -973
2.13	-1470/-2183	-38/-16	141/ 979	-1367/-1220
2.14	-1243/-1800	-66/ -4	141/ 979	-1168/ -825
		Advisory Committee		
2.11	-1142/-1665	-10/127	191/1175	-961/ -363
2.12	-973/-1424	-1/134	191/1175	-783/ -115
2.13	-1193/-1759	-10/127	191/1175	-1012/ -457
2.14	-980/-1442	13/143	191/1175	-776/ -124
		Combined		
2.11	-1315/-1904	-33/ 62	167/1093	-1181/ -749
2.12	-1083/-1687	-23/ 68	167/1093	-939/ -526
2.13	-1346/-1953	-33/ 62	167/1093	-1212/ -798
2.14	-1130/-1625	-7/ 79	167/1093	-970/ -453

Table 7.2. Ranked Alternatives by Least Regret

Natural Short Term/Long Term	Social Short Term/Long Term	Economic Short Term/Long Term	Total Short Term/Long Term
	Raw Score		
2.14/2.14	2.14/2.14	All equal	2.14/2.14
2.12/2.13	2.12/2.12*		2.12/2.13
2.11/2.12	*2.11/2.11*		2.11/2.12
2.13/2.11	*2.13/2.13*		2.13/2.11
	Weighted Score		
	Steering Committee		
2.14/2.14	2.13/2.14	All equal	2.14/2.14
2.12/2.12	2.12/2.12		2.12/2.12
2.11/2.11	*2.11/2.11*		2.13/2.11
2.13/2.13	*2.14/2.13*		2.11/2.13
	Advisory Committee		
2.12/2.12	2.14/2.14	All equal	2.14/2.12
2.14/2.14	2.12/2.12		2.12/2.14
2.11/2.11	*2.11/2.11*		2.11/2.11
2.13/2.13	*2.13/2.13*		2.13/2.13
	Combined		
2.12/2.14	2.14/2.14	All equal	2.12/2.14
2.14/2.12	2.12/2.12		2.14/2.12
2.11/2.11	*2.11/2.11*		2.11/2.11
2.13/2.13	*2.13/2.13*		2.13/2.13

*Received equal scores (Table 7.1)

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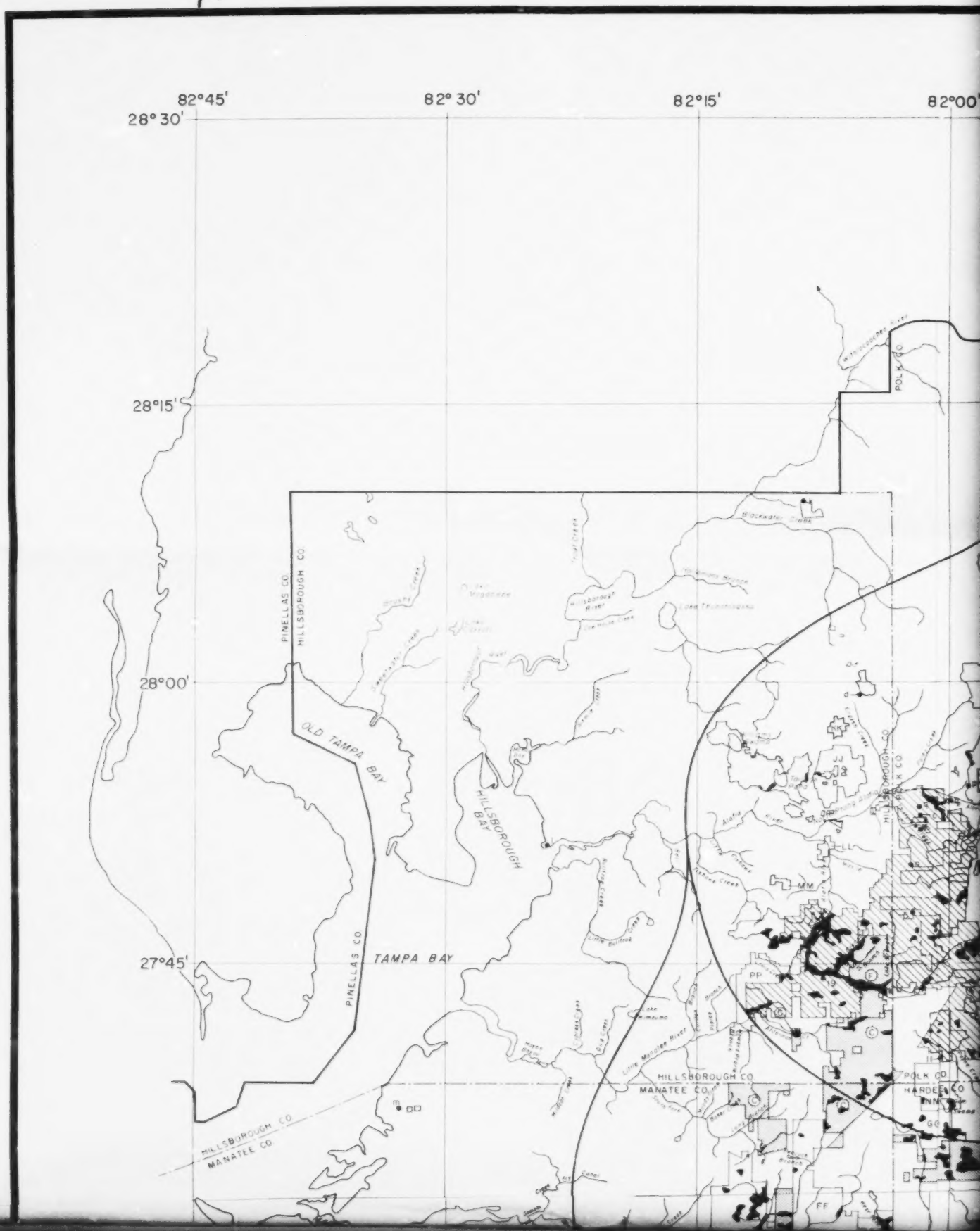
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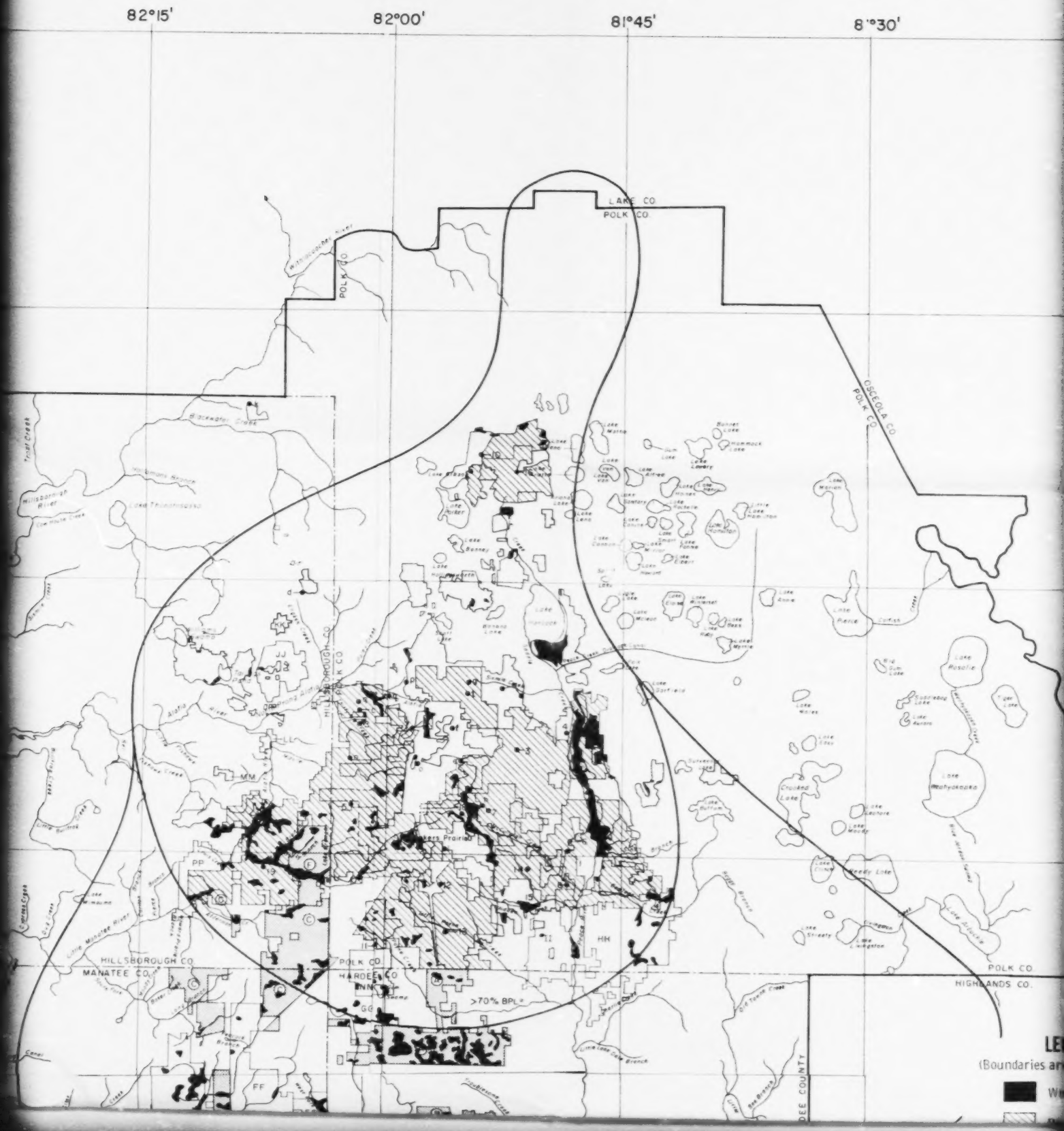
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POLK CO.
HARDEE CO.
POLK CO.
HIGHLANDS CO.
>70% BPL
Lake Parker
Lake Hancock
Lake Pierce
Lake Rosalie
Lake Wahyokapka
Crooked Lake
Reedy Lake
Lake Arbuckle
Lake Streety
Lake Livingston
Lake Marion
Lake Annie
Lake Garfield
Lake Buffum
Lake Leatore
Lake Moody
Lake Elbert
Lake Hamilton
Lake Alfred
Lake Van
Lake Eloise
Lake Mariana
Lake Wimauma
Little Manatee River
Alafia River
Hillsborough River
Withlacoochee River
Blackwater Creek
Lake Thonotosassa
Trout Creek
Cow House Creek
Little Buffalo Creek
Little Lake Gate Branch
Old Town Creek
Peace River
Peace River Canal
Saddlebag Lake
Big Gum Lake
Tiger Lake
Catfish Creek
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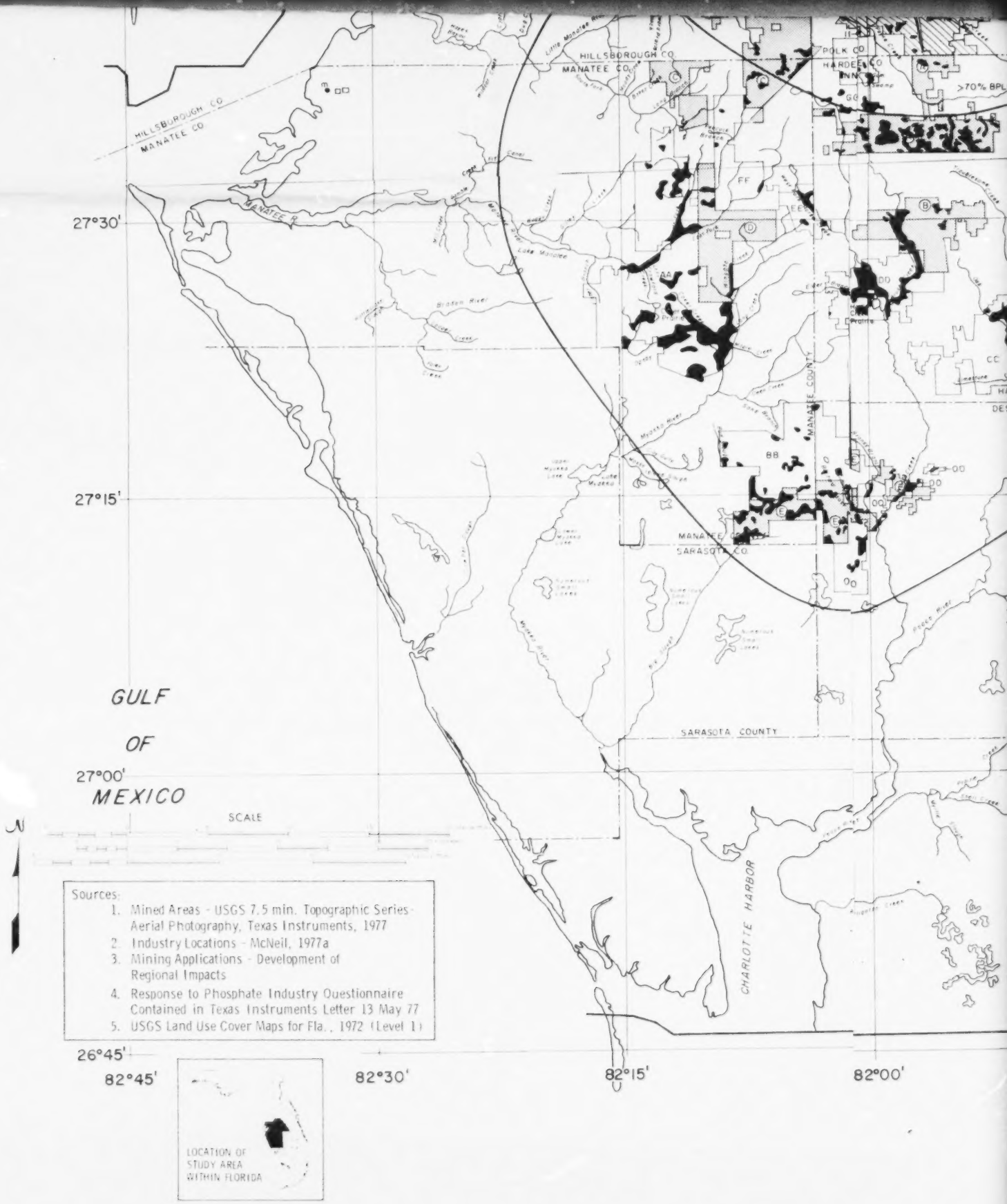
HIGHLANDS CO.
LEGEND
(Boundaries are Approximations)
Wetlands



Sources:

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2. Industry Locations - McNeil, 1977a
3. Mining Applications - Development of Regional Impacts
4. Response to Phosphate Industry Questionnaire Contained in Texas Instruments Letter 13 May 77
5. USGS Land Use Cover Maps for Fla., 1972 (Level 1)

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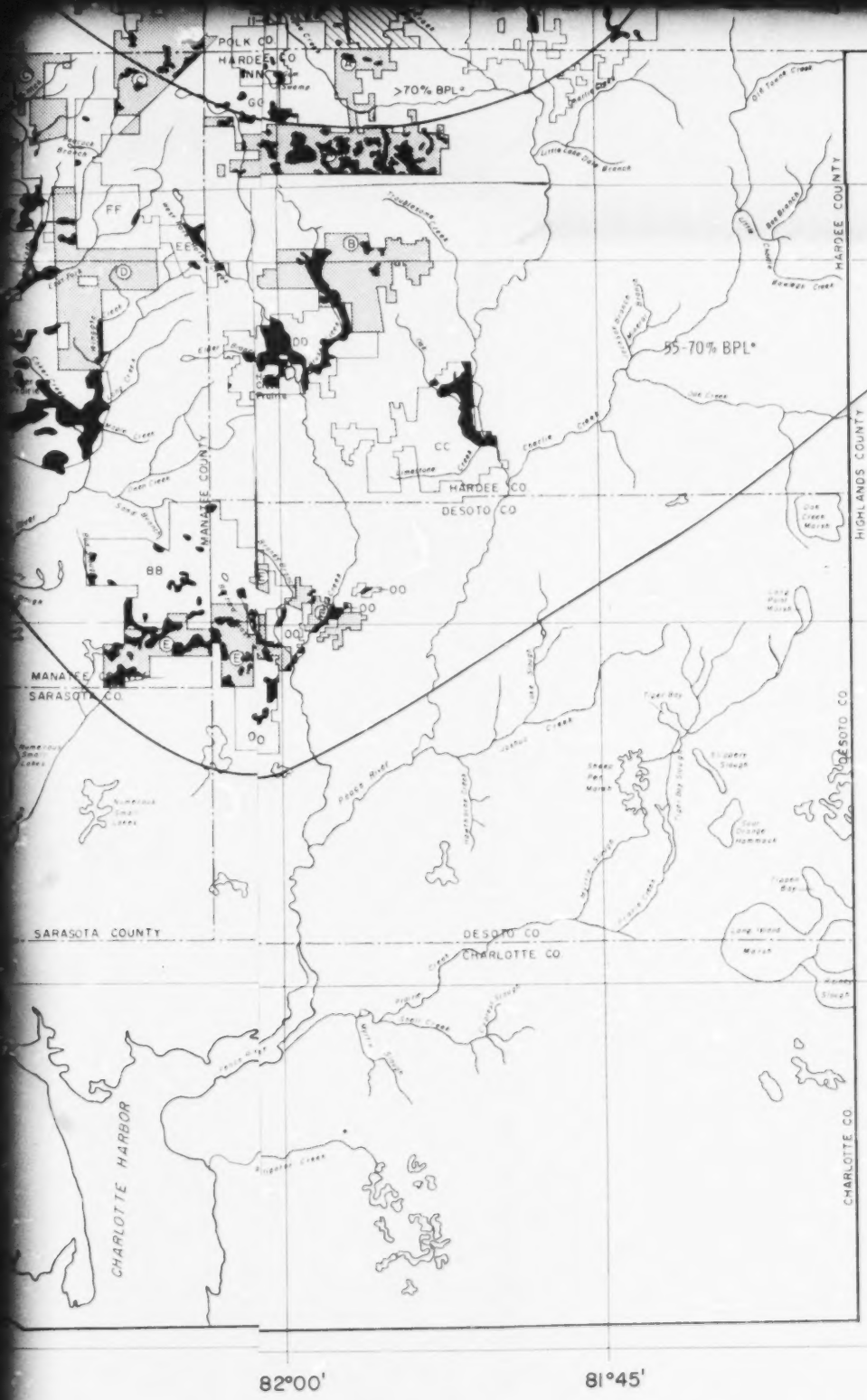

LEGEND

(Boundaries are Approximations)

- Wetlands
- Presently Permitted
- Existing Mined Areas
- Pending Permits
- Projected Mines (Applications to Submitted by 2000 A. D.)

Industrial Minerals and Rocks. American Institute of Mining, Metall and Petroleum Engineers. 1960. Third Edition. p. 654-After USGS Bu

CHEMICAL PROCESSING

a. USS Agri-Chem. - Bartow (2 Plant)
b. Royster Co. - Mulberry
c. Conserv., Inc.
d. Borden. - Plant City
e. Farmland Industries - Bartow
f. C. F. Chemicals - Bartow
g. W. R. Grace Chemical - Bartow
h. Swift - Silver City
i. Agrico - South Pierce
j. USS Agri-Chem. - Ft. Meade
k. C. F. Chemicals - Plant City
l. Gardinier Inc. - East Tampa
m. Borden, Inc. - Palmetto
n. IMC - New Wales
o. Agrico - Pierce (Drying Only)
p. C. F. Industries - Mulberry
q. Mobil Oil Co. - Nichols Preparation Plant

BENEFICIATION PLANTS/MIN (See Text for Estimated Mine L

1. W. R. Grace - Bonny Lak
2. Mobil Oil Co. - Nichols T
3. IMC - Noralyn
4. IMC - Clear Spr in
5. IMC - Kingsford
6. Mobil Oil Co. - Ft. Meade
7. Swift - Silver City
8. Swift - Watson Mine
9. Brewster Phosphates - H Mine
10. Agrico - Saddle Creek Mi
11. Agrico - Ft. Green Mine
12. Agrico - Palmetto Mine
13. Agrico - Payne Creek Mi
14. USS Agri-Chem. - Rock
15. Gardinier, Inc. - Ft. Me
16. Borden - Teneroc Mine
17. T.A. Minerals, Inc.
18. W. R. Grace - Hooker's
19. Brewster Phosphates - L

MINING APPLICATIONS SUBMITTED

(As of 1 Aug. '76) (See Text for Estimated Start Up and Longevity

(A) I. F. Mining Corporation
(B) Mississippi Chemical Corporation
(C) W. R. Grace & Company
(D) Baker Phosphate Corpora
(E) Phillips Petroleum Comp
(F) Borden

Projected Mines

(See Text for Estimated Start Up and Longevity)

AA - W. R. Grace
BB - IMC
CC - Freeport
DD - IMC
EE - USS Agri-Chem.
FF - Swift
GG - USS Agri-Chem.
HH - Mobil
II - USS Agri-Chem./Gardinier (Little Payne Mine)
JJ - Brewster Phosphate
KK - Brewster Phosphate
LL - Brewster Phosphate
MM - Brewster Phosphate
NN - Stauffer
OO - Noranda
PP - Farmland
QQ - Florida Phosphate M

CENTRAL FLORIDA PHOSPH

PLATE 1 Volume VII

RELATIONSHIP OF EXISTING PROJECTED PHOSPHATE INDU ACTIVITIES TO WATERS OF AND WETLANDS

Prepared by

TEXAS INSTRUMENTS
INCORPORATED

EPA Contract Number 68-01-4196

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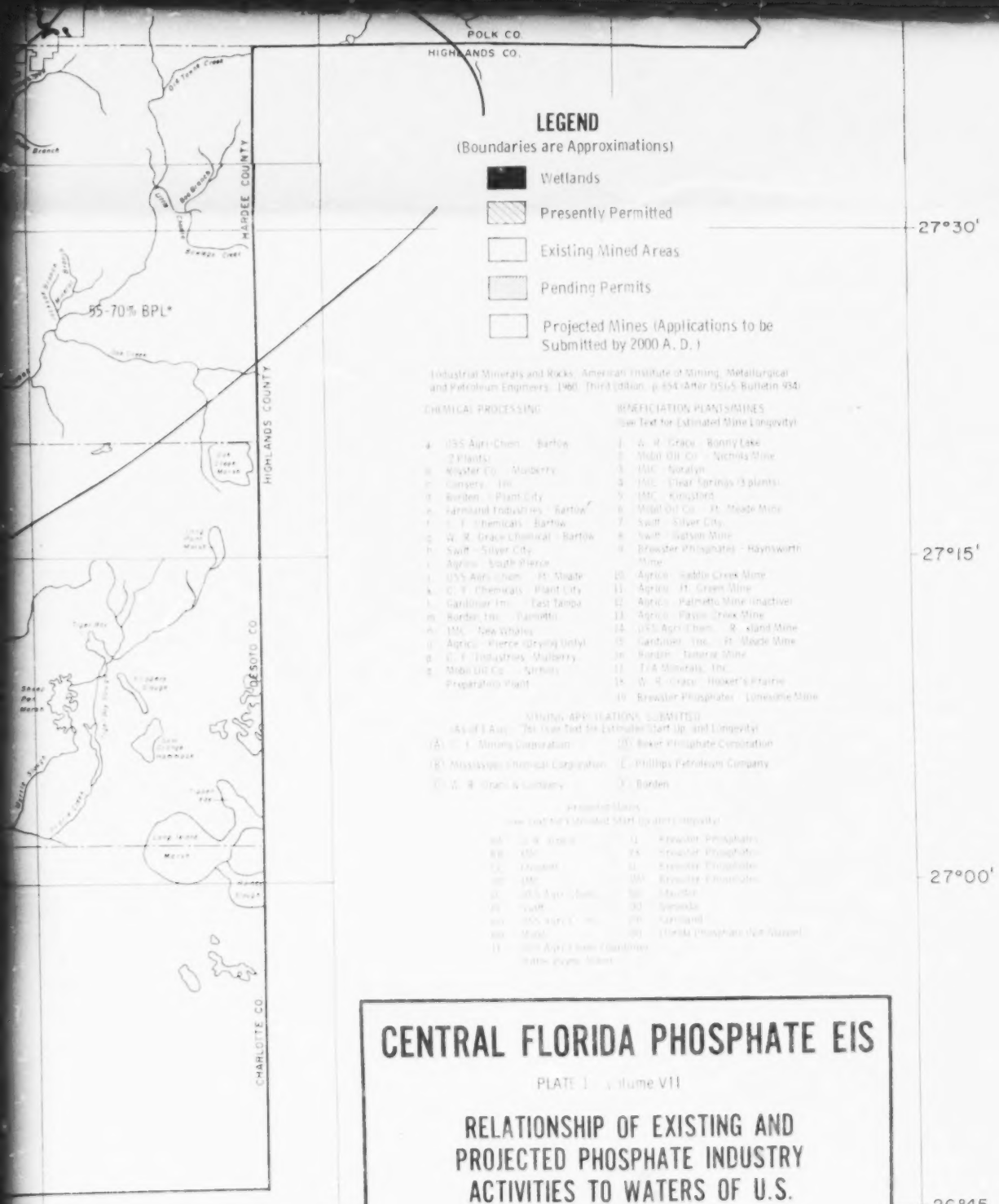

LEGEND

(Boundaries are Approximations)

- Wetlands
- Presently Permitted
- Existing Mined Areas
- Pending Permits
- Projected Mines (Applications to be Submitted by 2000 A. D.)

Industrial Minerals and Rocks, American Institute of Mining, Metallurgical and Petroleum Engineers, 1960, Third Edition, p.654 (After USGS Bulletin 934)

CHEMICAL PROCESSING

a. USS Agri-Chem - Bartow (2 Plants)
b. Royster Co. - Mulberry
c. Cargill - Tiff
d. Borden - Plant City
e. Farmland Industries - Bartow
f. C. F. Chemicals - Bartow
g. W. R. Grace Chemical - Bartow
h. Swift - Silver City
i. Agrico - South Pierce
j. USS Agri-Chem - Ft. Meade
k. C. F. Chemicals - Plant City
l. Gardinier Inc. - East Tampa
m. Borden Inc. - Palmetto
n. IMC - New Wales
o. Agrico - Pierce (drying only)
p. C. F. Industries - Mulberry
q. Mobil Oil Co. - Nichols Preparation Plant

BENEFICIATION PLANTS/MINES
(See Text for Estimated Mine Longevity)

1. A. R. Grace - Bonny Lake
2. Mobil Oil Co. - Nichols Mine
3. IMC - Noralyn
4. IMC - Clear Springs (3 plants)
5. IMC - Kingsford
6. Mobil Oil Co. - Ft. Meade Mine
7. Swift - Silver City
8. Swift - Gotson Mine
9. Brewster Phosphates - Haynsworth Mine
10. Agrico - Saddle Creek Mine
11. Agrico - Ft. Green Mine
12. Agrico - Palmetto Mine (Inactive)
13. Agrico - Fagan Creek Mine
14. USS Agri-Chem - Rockland Mine
15. Gardinier, Inc. - Ft. Meade Mine
16. Borden - Tenoroc Mine
17. T.I.A Minerals, Inc.
18. W. R. Grace - Hooker's Prairie
19. Brewster Phosphates - Lonesome Mine

MINING APPLICATIONS SUBMITTED
(As of 1 Aug. '78) (See Text for Estimated Start Up and Longevity)

(A) C. F. Mining Corporation
(B) Mississippi Chemical Corporation
(C) W. R. Grace & Company
(D) Baker Phosphate Corporation
(E) Phillips Petroleum Company
(F) Borden

Projected Mines
(See Text for Estimated Start Up and Longevity)

AA. W. R. Grace
BB. IMC
CC. Cargill
DD. IMC
EE. USS Agri-Chem
FF. Swift
GG. USS Agri-Chem
HH. Mobil
II. USS Agri-Chem (Gardinier Saddle Creek Mine)
JJ. Brewster Phosphates
KK. Brewster Phosphates
LL. Brewster Phosphates
MM. Brewster Phosphates
NN. Mobil
OO. Seminole
PP. Farmland
QQ. Occidental Phosphates (Joe Mansell)

CENTRAL FLORIDA PHOSPHATE EIS

PLATE 1 Volume VII

RELATIONSHIP OF EXISTING AND PROJECTED PHOSPHATE INDUSTRY ACTIVITIES TO WATERS OF U.S. AND WETLANDS

Prepared by

TEXAS INSTRUMENTS

EPA Contract Number 68-01-4196

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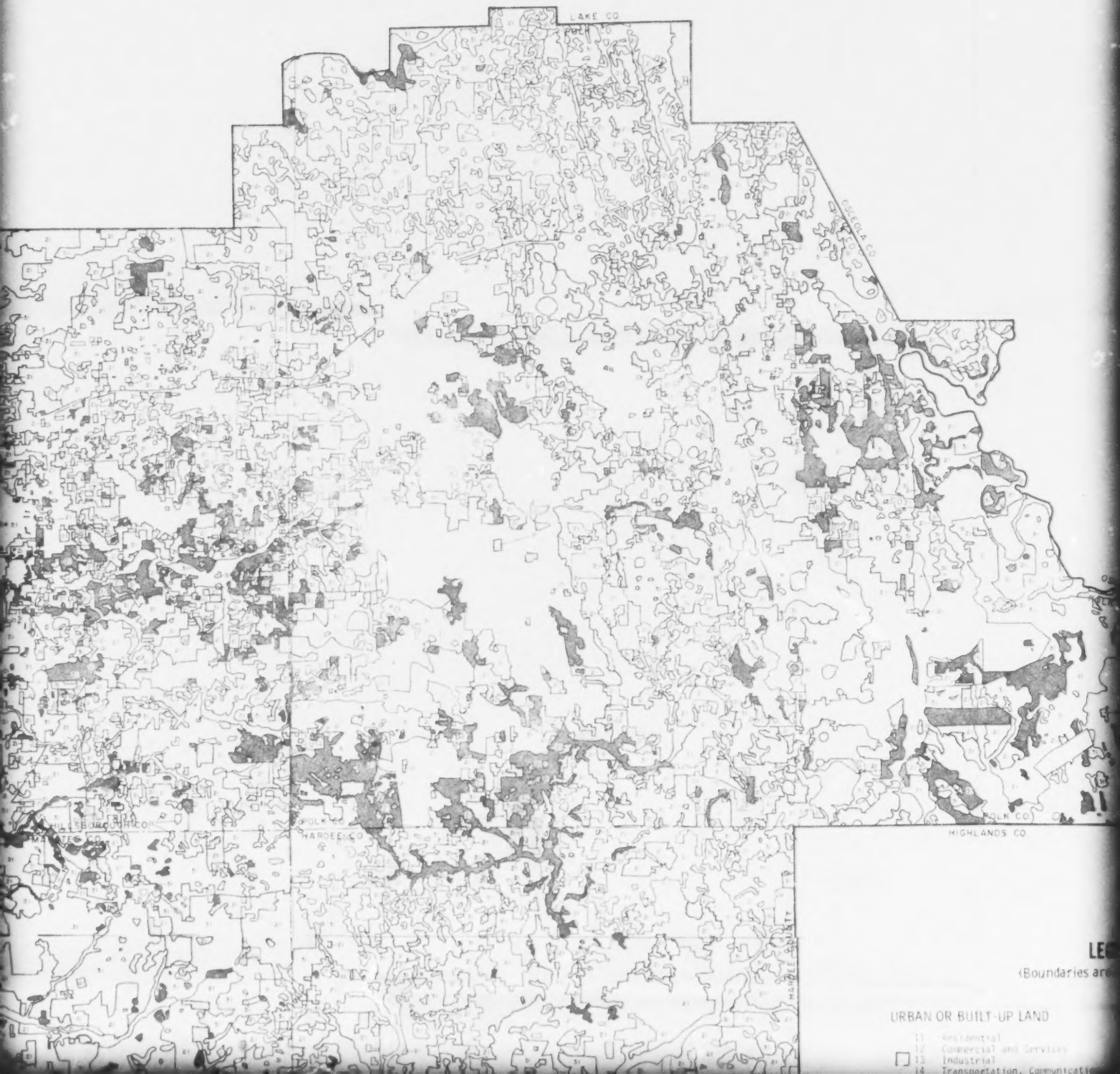
A

B

PINELLAS CO.
PINELLAS CO.
TAMPA BAY
HILLSBOROUGH CO.
MANATEE CO.
HILLSBOROUGH CO.
POLK CO.
HARDEE

B


LAKE CO
OSCEOLA CO
POLK CO
HARDEE CO
HIGHLANDS CO
HARDEE COUNTY
LE
(Boundaries ar
URBAN OR BUILT-UP LAND
11 Residential
12 Commercial and Services
13 Industrial
14 Transportation, Communicatio

C

LEGEND

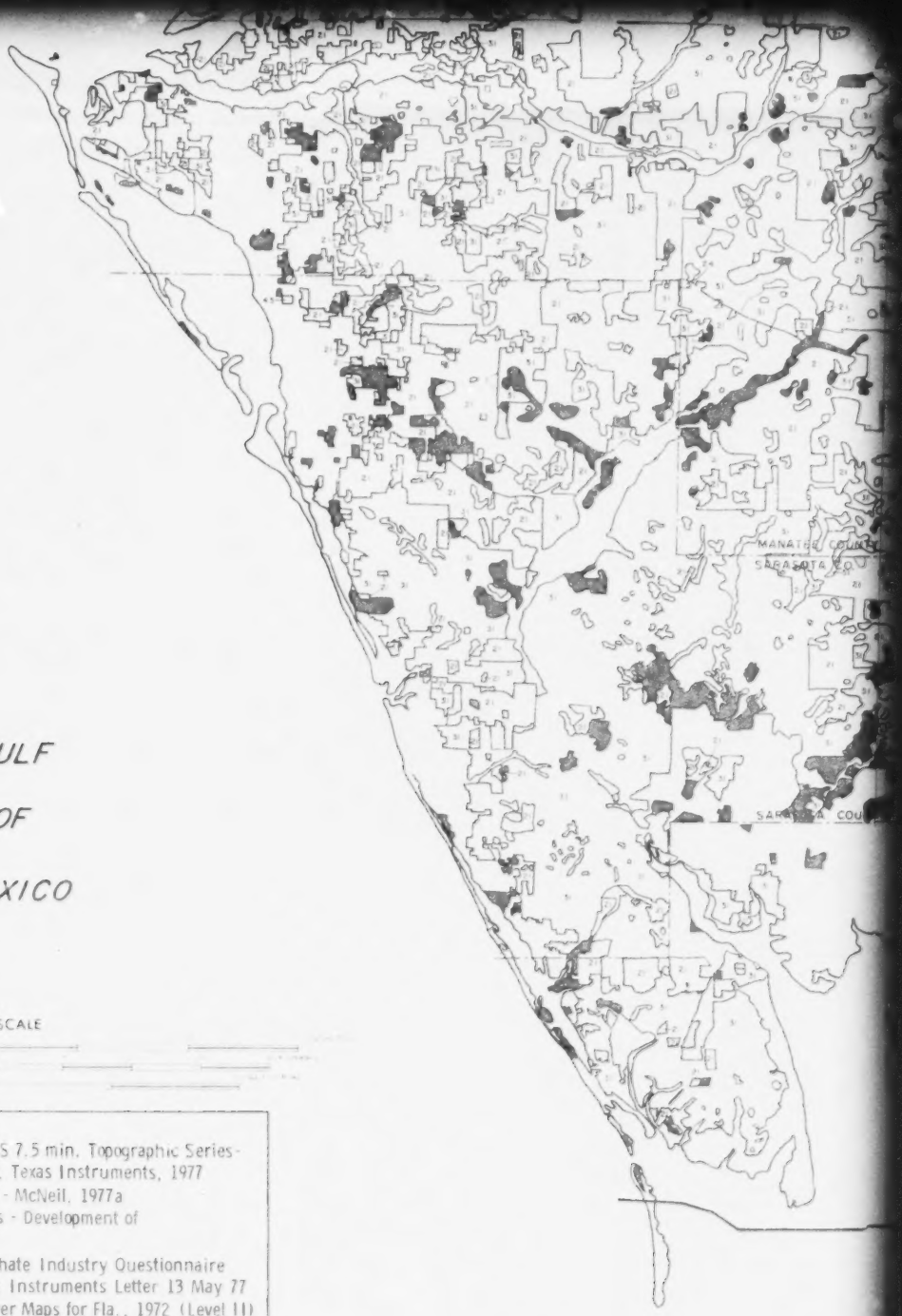
(Boundaries are Approximations)

URBAN OR BUILT-UP LAND

11 Residential

WETLAND

61 Forested Wetland
62 Nonforested Wetland



GULF

OF

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SCALE

Sources:

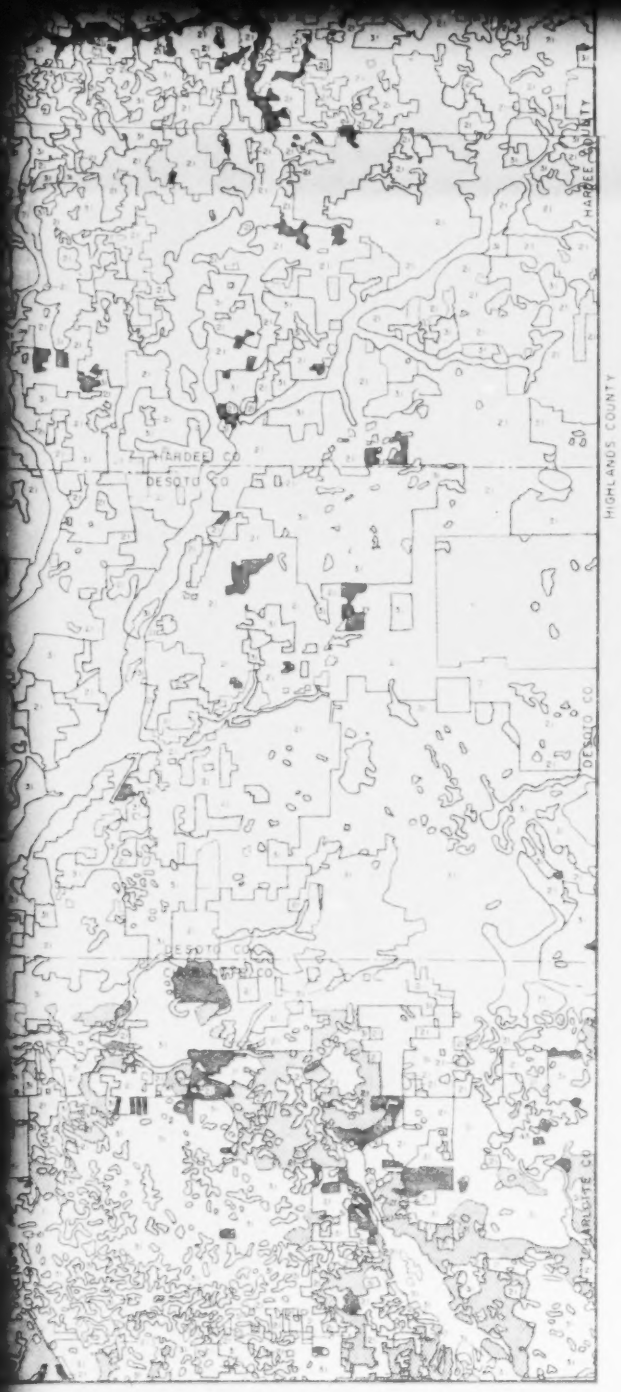
1. Mined Areas - USGS 7.5 min. Topographic Series- A[illegible]hotography, Texas Instruments, 1977
2. Industry Locations - McNeil, 1977a
3. Mining Applications - Development of Regional Impacts
4. Response to Phosphate Industry Questionnaire Contained in Texas Instruments Letter 13 May 77
5. USGS Land Use Cover Maps for Fla., 1972 (Level II)
6. Florida Department of Transportation

D

E

HARDEE CO
DESOTO CO
MANATEE COUNTY
MANATEE COUNTY
SARASOTA CO
SARASOTA COUNTY
DESOTO CO
DESOTO CO
HIGHLANDS COUNTY
CHARLOTTE CO

E



LEGEND

(Boundaries are Approximations)

URBAN OR BUILT-UP LAND

- 11 Residential
- 12 Commercial and Services
- 13 Industrial
- 14 Transportation, Communications and Utilities
- 15 Industrial and Commercial Complexes
- 16 Mixed Urban or Built-up Land
- 17 Other Urban or Built-up Land

AGRICULTURAL LAND

- 21 Cropland and Pasture
- 22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
- 23 Confined Feeding Operations
- 24 Other Agricultural Land

RANGELAND

- 31 Herbaceous Rangeland
- 32 Shrub and Brush Rangeland
- 33 Mixed Rangeland

FOREST LAND

- 41 Deciduous Forest Land
- 42 Evergreen Forest Land
- 43 Mixed Forest Land

WATER

- 51 Streams and Canals
- 52 Lakes
- 53 Reservoirs
- 54 Bays and Estuaries

WETLAND

- 61 Forested Wetland
- 62 Nonforested Wetland

BARREN LAND

- 71 Dry Salt Flats
- 72 Beaches
- 73 Sandy Areas Other than Beaches
- 74 Bare Exposed Rock
- 75 Strip Mines, Quarries, and Gravel Pits
- 76 Transitional Areas
- 77 Mixed Barren Land

PRODUCTION AREAS

ALTERNATIVES

1977-2000

- PERMITTED AS OF 1 AUG '76
- PENDING
- PROJECTED PER INDUSTRY LAND USE PLANS

CENTRAL FLORIDA PHOSPHATE EIS

PLATE 2 - Volume VII

RELATIONSHIP OF PHOSPHATE INDUSTRY LAND USE MANAGEMENT PROJECTIONS TO PRESENT LAND USE

Prepared by

TEXAS INSTRUMENTS

EPA Contract Number 68-01-4196

F

A

PLATE 3 - Volume VII

ENVIRONMENTAL EFFECTS MATRIX FOR CENTRAL FLORIDA PHOSPHATE INDUSTRY

SCENARIO

					AQUATIC BIOTA													TERRESTRIAL B					
									STANDING WATERS			RUNNING WATERS			BAYS AND ESTUARIES							UPLAND	
					THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	RESOURCE POTENTIAL	HABITAT QUALITY	COMMUNITY STRUCTURE	FLOW REGIME	HABITAT QUALITY	COMMUNITY STRUCTURE	FRESHWATER DISCHARGE PATTERNS	HABITAT QUALITY	COMMUNITY STRUCTURE	THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	AREAL EXTENT	HABITAT QUALITY
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
OLOGICAL DEMAND ELEMENTS	TIVITIES	EXPLORATION/MINING	DRILLING	PROSPECT DRILLING	1																		
				WATER WELL DRILLING	2																		
			LAND PREPARATION	DRAINING/DEWATERING	3																		
				CLEARING	4																		
				BURNING	5																		
			LAND EXCAVATION	DRAGLINING	6																		
				DREDGING	7																		
				OVERBURDEN PLACEMENT	8																		
				WATER EXTRACTION	9																		
				WATER INJECTION	10																		
				EQUIPMENT RELOCATION	11																		
		WASHING/ BENEFICIATION		PRODUCT STORAGE	12																		
				PRODUCT DRYING	13																		
				TAILINGS PLACEMENT	14																		
				SLIME PLACEMENT	15																		
				WATER USE/RECYCLE	16																		
		SING	NUFACTURING	SULFURIC ACID	17																		
				FERTILIZER PRODUCTS	18																		
				ANIMAL GRADE PHOSPHATE	19																		

B

ENVIRONMEN

NATURAL RESOURCES

	AQUATIC BIOTA									TERRESTRIAL BIOTA										PHYSICAL AND HYDROLOGICAL ELEMENTS															
		STANDING WATERS			RUNNING WATERS			BAYS AND ESTUARIES						UPLANDS			WETLANDS			LAND						SURFACE WATER		SUBSURFACE WATER				HYDROLOGI PROCESS		
																												WATER TABLE		FLORIDAN AQUIFER				
NUISANCE AND PEST SPECIES	RESOURCE POTENTIAL	HABITAT QUALITY	COMMUNITY STRUCTURE	FLOW REGIME	HABITAT QUALITY	COMMUNITY STRUCTURE	FRESHWATER DISCHARGE PATTERNS	HABITAT QUALITY	COMMUNITY STRUCTURE	THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE	MINERAL RESOURCES	UNIQUE PHYSICAL FEATURES	SOILS	EXPOSURE	TOPOGRAPHY	BACKGROUND RADIATION	QUALITY	QUANTITY	QUALITY	QUANTITY	QUALITY	QUANTITY	AQUIFER RECHARGE	EROSION	FLOODING
4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	[illegible]

ENVIRONMENTAL DEMAND ELEMENTS C

YSICAL AND HYDROLOGICAL ELEMENTS												SOCIAL RESOURCES																			
												ANXIETY FACTORS							COMMUNITY							MAN-MADE (OR MAN-ORIENTED)					
SURFACE WATER		SUBSURFACE WATER				HYDROLOGICAL PROCESSES				ATMOSPHERE																					RECREA
		WATER TABLE		FLORIDAN AQUIFER																											
QUALITY	QUANTITY	QUALITY	QUANTITY	QUALITY	QUANTITY	AQUIFER RECHARGE	EROSION	FLOODING	CAVITATION	CLIMATE/WEATHER	AIR QUALITY	AIR	WATER	RADIATION	NOISE	PERSONAL PROPERTY	UTILITIES	VISUAL DEGRADATION	COHESION	SPATIAL GROWTH	DENSITY	DIVERSITY	ACCESSIBILITY OF FACILITIES AND SERVICES	DISPLACEMENT	MOBILITY	TRANSPORTATION	HOUSING	CULTURAL OPPORTUNITIES	AESTHETICS	ARCHEOLOGICAL AND HISTORICAL SITES	WATER BASED
30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61

ESOURCES	MAN-MADE (MAN-ORIENTED)		59 AESTHETICS
			60 ARCHEOLOGICAL AND HISTORICAL SITES
		RECREATION	61 WATER BASED
			62 LAND BASED
	LAND TENURE		63 PUBLIC LAND
			64 PRIVATE LAND
	LAND USE		65 REGIONAL AND COMMUNITY PLANS
			66 RESIDENTIAL DEVELOPMENT
			67 COMMERCIAL DEVELOPMENT
			68 INDUSTRIAL DEVELOPMENT
			69 MINING
			70 FORESTS
			71 AGRICULTURE
			72 OPEN SPACE
ECONOMIC RESOURCES			73 NATIONAL ECONOMIC DEVELOPMENT
			74 STATE ECONOMIC DEVELOPMENT
	LOCAL		75 TAX REVENUE
			76 PROPERTY VALUES
	PUBLIC FACILITIES AND SERVICES		77 EDUCATIONAL
			78 HEALTH
			79 FIRE/POLICE PROTECTION
			80 WATER SUPPLY
			81 ELECTRICAL SERVICE
			82 WASTE TREATMENT AND DISPOSAL
			83 STREETS AND ROADS
		LOCAL/ REGIONAL ACTIVITY	84 TRENDS IN LOCAL ECONOMIC DEVELOPMENT
			85 TRENDS IN REGIONAL ECONOMIC DEVELOPMENT
			86 EMPLOYMENT/LABOR FORCE
			87 AGRICULTURAL ACTIVITY
			88 BUSINESS AND INDUSTRIAL ACTIVITY - MAJOR ECONOMIC, NON-PHOSPHATE
			89 ECONOMIC GEOLOGIC RESOURCES
			90 BALANCE OF TRADE
			9 NATIONAL DEFENSE OR SELF SUFFICIENCY

D

TECHNOLOGICAL DEM

PRIMARY ACTIVITIES	WAS BENEF	SLIME PLACEMENT	15	
		WATER USE/RECYCLE	16	
	PROCESSING	MANUFACTURING: SULFURIC ACID	17	
		MANUFACTURING: FERTILIZER PRODUCTS	18	
		MANUFACTURING: ANIMAL GRADE PHOSPHATE	19	
		MANUFACTURING: ELEMENTAL PHOSPHORUS	20	
		WASTE TREATMENT	21	
		WASTE PLACEMENT	22	
		WATER USE/RECYCLE	23	
	CONSTRUCTION	DAMS AND LEVEES	24	
		TRANSPORTATION LINES	25	
		UTILITY LINES	26	
		WASHING/BENEFICIATION PLANTS	27	
		PROCESSING PLANTS	28	
		DRAINAGE SYSTEMS	29	
	RECLAMATION	TRANSPORTATION SYSTEMS	30	
		MINING PITS	31	
		SLIME PONDS	32	
		UTILITY SYSTEMS	33	
		PLANT SITES	34	
		DAMS AND LEVEES	35	
		SUPPORT FACILITIES	36	
	TRANSPORTATION	MINE PRODUCTS	37	
		WASHING/BENEFICIATION PRODUCTS	38	
		SULFURIC ACID PLANT PRODUCTS	39	
		PHOSPHATE PLANT PRODUCTS	40	
		WATER	41	
		PEOPLE	42	
		SUPPORT PRODUCTS	43	
SECONDARY ACTIVITIES	SUPPORT ACTIVITIES	MINING	44	
		WASHING/BENEFICIATION	45	
		PROCESSING	46	
		RECLAMATION	47	
		TRANSPORTATION	48	
		LAND ACQUISITION	49	
		RESEARCH AND DEVELOPMENT	50	
		GOVERNMENT AND PUBLIC RELATIONS	51	

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ENVIRONMENTAL EFFECTS MATRIX FOR CENTRAL FLORIDA PHOSPHATE INDUSTRY

SCENARIO
PLATE 4 - Volume VII

PERMIT EXISTING AND NEW SOURCES

				AQUATIC BIOTA													TERRESTRIAL BI						
								STANDING WATERS			RUNNING WATERS			BAYS AND ESTUARIES							UPLANDS		
				THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	RESOURCE POTENTIAL	HABITAT QUALITY	COMMUNITY STRUCTURE	FLOW REGIME	HABITAT QUALITY	COMMUNITY STRUCTURE	FRESHWATER DISCHARGE PATTERNS	HABITAT QUALITY	COMMUNITY STRUCTURE	THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
EXPLORATION/MINING	DRILLING	PROSPECT DRILLING	1																				
		WATER WELL DRILLING	2																				
	LAND PREPARATION	DRAINING/DEWATERING	3	-1		-1	+1	-1	-1	-1	-1	-1	-1									-1	-1
				-2		-1	+2	-2	-2	-2	-1	-1	-1									-1	-1
		CLEARING	4	-1		-2			-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
				-1		-2			-2	-2	-2	-2	-2	-1	-2	-1	-1	-1	-1	-1	-1	-1	-1
		BURNING	5																				
	LAND EXCAVATION	DRAGLINING	6	-2		-1	+1	-1	-1	-1	-1	-1	-1	0			-4	-4	-1	-1	-4	-1	-4
				-2		-1	+1	-2	-2	-2	-1	-1	-1	-1			-8	-6	-1	-1	-8	-1	-6
		DREDGING	7	-1		-1	+1	-1	-1	-1	-1	-1	-1	0									
				-2		-1	+1	-2	-2	-2	-1	-1	-1	-1									
	OVERBURDEN PLACEMENT		8																				
	WATER EXTRACTION		9																				
	WATER INJECTION		10																				
	EQUIPMENT RELOCATION		11																				
WASHING/ BENEFICIATION	PRODUCT STORAGE		12																				
	PRODUCT DRYING		13																		-1		
																					-1		
	TAILINGS PLACEMENT		14																				
	SLIME PLACEMENT		15	-2		-2	-1		-2	-2	-1	-2	-2	-1	-2	-2	-1	-1	-1	-1	-1	-1	-1
				-4		-4	-2		-4	-4	-2	-4	-4	-2	-4	-4	-1	-1	-1	-1	-1	-1	-1
	WATER USE/RECYCLE		16	0		0	-1	+1			+1	+1	+1	+1	+1	+1							
				-1		-1	-1	+2			+1	+1	+1	+1	+1	+1							
ING	UFACTURING	SULFURIC ACID	17			-1			-1	-1		-1	-1		-1	-1						-1	
						-1			-1	-1		-1	-1		-1	-1						-1	
		FERTILIZER PRODUCTS	18			-1			-1	-1		-1	-1		-1	-1							
						-1			-1	-1		-1	-1		-1	-1							
		ANIMAL GRADE PHOSPHATE	19			-1			-1	-1		-1	-1		-1	-1							
						-1			-1	-1		-1	-1		-1	-1							

IVITIES

OLOGICAL DEMAND ELEMENTS

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ENVIRONMENTAL DEMAND ELEMEN

11	12 HABITAT QUALITY	13 COMMUNITY STRUCTURE	14 THREATENED AND ENDANGERED SPECIES	15 ECOLOGICALLY SIGNIFICANT SPECIES	16 COMMERCIAL AND RECREATIONAL SPECIES	17 NUISANCE AND PEST SPECIES	18 AREAL EXTENT	19 HABITAT QUALITY	20 COMMUNITY STRUCTURE	21 AREAL EXTENT	22 HABITAT QUALITY	23 COMMUNITY STRUCTURE	24 MINERAL RESOURCES	25 UNIQUE PHYSICAL FEATURES	26 SOILS	27 EXPOSURE	28 TOPOGRAPHY	29 BACKGROUND RADIATION	30 QUALITY	31 QUANTITY	32 QUALITY	33 QUANTITY	34 QUALITY	35 QUANTITY	36 AQUIFER RECHARGE	37 EROSION	38 FLOODING	39 CAVITATION	40 CLIMATE/WEATHER	41 AIR QUALITY	42 AIR	43 WATER
	NATURAL RESOURCES																														ANXI	
	AYS AND STUARIES		TERRESTRIAL BIOTA				UPLANDS			WETLANDS			PHYSICAL AND HYDROLOGICAL ELEMENTS: LAND						SURFACE WATER		SUBSURFACE WATER: WATER TABLE		SUBSURFACE WATER: FLORIDAN AQUIFER		HYDROLOGICAL PROCESSES				ATMOSPHERE			
								-1	-1		-1	-1																				
								-1	-1		-1	-1																				
1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0						-5													
1	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1						-5													
																			-5													
																			-5													
			-4	-4	-1	-1	-4	-1	-4	-10	-1	-4	-1																			
			-8	-6	-1	-1	-8	-1	-6	-10	-1	-8	-3																			
																						+1										
																						0										
											-1													-3								
											-1													0								
							-1				-1																					
							-1				-1																					
1	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1							-7													
2	-4	-4	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1							-7													
1	+1	+1																					-1									
1	+1	+1																					-1									
	-1	-1						-1			-1													-3								
	-1	-1						-1			-1													0								
	-1	-1																														
	-1	-1																														
	-1	-1																														

TAL DEMAND ELEMENTS C

			SOCIAL RESOURCES																													
			ANXIETY FACTORS							COMMUNITY							MAN-MADE (OR MAN-ORIENTED)							LAND TENURE		LAND USE						
EAL S	ATMOSPHERE																					RECREATION										
CAVITATION	CLIMATE/WEATHER	AIR QUALITY	AIR	WATER	RADIATION	NOISE	PERSONAL PROPERTY	UTILITIES	VISUAL DEGRADATION	COHESION	SPATIAL GROWTH	DENSITY	DIVERSITY	ACCESSIBILITY OF FACILITIES AND SERVICES	DISPLACEMENT	MOBILITY	TRANSPORTATION	HOUSING	CULTURAL OPPORTUNITIES	AESTHETICS	ARCHEOLOGICAL AND HISTORICAL SITES	WATER BASED	LAND BASED	PUBLIC LAND	PRIVATE LAND	REGIONAL AND COMMUNITY PLANS	RESIDENTIAL DEVELOPMENT	COMMERCIAL DEVELOPMENT	INDUSTRIAL DEVELOPMENT	MINING	FORESTS	AGRICULTURE
39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71

	62	LAND BASED	NTION
LAND TENURE	63	PUBLIC LAND	
	64	PRIVATE LAND	
LAND USE	65	REGIONAL AND COMMUNITY PLANS	
	66	RESIDENTIAL DEVELOPMENT	
	67	COMMERCIAL DEVELOPMENT	
	68	INDUSTRIAL DEVELOPMENT	
	69	MINING	
	70	FORESTS	
	71	AGRICULTURE	
	72	OPEN SPACE	
ECONOMIC RESOURCES	73	NATIONAL ECONOMIC DEVELOPMENT	
	74	STATE ECONOMIC DEVELOPMENT	
LOCAL	75	TAX REVENUE	
	76	PROPERTY VALUES	
PUBLIC FACILITIES AND SERVICES	77	EDUCATIONAL	
	78	HEALTH	
	79	FIRE/POLICE PROTECTION	
	80	WATER SUPPLY	
	81	ELECTRICAL SERVICE	
	82	WASTE TREATMENT AND DISPOSAL	
	83	STREETS AND ROADS	
LOCAL/ REGIONAL ACTIVITY	84	TRENDS IN LOCAL ECONOMIC DEVELOPMENT	
	85	TRENDS IN REGIONAL ECONOMIC DEVELOPMENT	
	86	EMPLOYMENT/LABOR FORCE	
	87	AGRICULTURAL ACTIVITY	
	88	BUSINESS AND INDUSTRIAL ACTIVITY – MAJOR ECONOMIC, NON-PHOSPHATE	
	89	ECONOMIC GEOLOGIC RESOURCES	
	90	BALANCE OF TRADE	
	91	NATIONAL DEFENSE OR SELF SUFFICIENCY	

D

TECHNOLOGICAL DEMAN

PRIMARY ACTIVITIES	WASHI BENEFIC	TAILINGS PLACEMENT	14																				
		SLIME PLACEMENT	15	-2 / -4		-2 / -4	-1 / -2		-2 / -4	-2 / -4	-1 / -2	-2 / -4	-2 / -4	-1 / -2	-2 / -4	-2 / -4	-1 / -1	-1 / -1	-1 / -1	-1 / -1	-1 / -1	-1 / -1	-1 / -1
		WATER USE/RECYCLE	16	0 / -1		0 / -1	-1 / -1	+1 / +2			+1 / +1	+1 / +1	+1 / +1	+1 / +1	+1 / +1	+1 / +1							
	PROCESSING	SULFURIC ACID	17			-1 / -1			-1 / -1	-1 / -1		-1 / -1	-1 / -1		-1 / -1	-1 / -1						-1 / -1	
		FERTILIZER PRODUCTS	18			-1 / -1			-1 / -1	-1 / -1		-1 / -1	-1 / -1		-1 / -1	-1 / -1							
		ANIMAL GRADE PHOSPHATE	19			-1 / -1			-1 / -1	-1 / -1		-1 / -1	-1 / -1		-1 / -1	-1 / -1							
		ELEMENTAL PHOSPHORUS	20																				
		WASTE TREATMENT	21																				
		WASTE PLACEMENT	22	+1 / +2		+1 / +2	-1 / -2		-1 / -1	-1 / -1	+1 / +1	+1 / +1	+1 / +1		+2 / +2	+2 / +2						-1 / -1	
		WATER USE/RECYCLE	23	+1 / +1		+1 / +1	-1 / -2	+1 / +2			+1 / +1	+1 / +1	+1 / +1	+1 / +1	+1 / +1	+1 / +1							
	CONSTRUCTION	DAMS AND LEVEES	24	-1 / -1		-1 / -1	-1 / -2	+1 / +2	-1 / -2	-1 / -2	-1 / -2	-1 / -2	-1 / -2	-1 / -2	-1 / -1	-1 / -1						-1 / -1	
		TRANSPORTATION LINES	25																				
		UTILITY LINES	26																				
		WASHING/BENEFICIATION PLANTS	27																				
		PROCESSING PLANTS	28																				
		DRAINAGE SYSTEMS	29	-1 / -1		-1 / -2	+1 / +2	-1 / -2	-1 / -2	-1 / -2	-1 / -2	-1 / -2	-1 / -2	-1 / -1	-1 / -1	-1 / -1						-1 / -1	
	RECLAMATION	TRANSPORTATION SYSTEMS	30																				
		MINING PITS	31	+1 / +2		+2 / +4	-1 / -2	+2 / +4			-2 / -4	-1 / -2	-1 / -2	-1 / -2	-1 / -2	-1 / -2	-4 / -6	-2 / -4	-1 / -1	-1 / -1	-2 / -6	-1 / -1	-4 / -8
		SLIME PONDS	32	+2 / +4		+2 / +4	+1 / +2		+2 / +4	+2 / +4	+1 / +2	+2 / +4	+2 / +4	+1 / +2	+2 / +4	+2 / +4	-1 / -1	-1 / -1	-1 / -1	-1 / -1	-1 / -1	-1 / -1	-1 / -1
		UTILITY SYSTEMS	33																				
		PLANT SITES	34																				
		DAMS AND LEVEES	35	+1 / +1		+1 / +1	+1 / +2	-1 / -2	+1 / +2	+1 / +2	+1 / +2	+1 / +2	+1 / +2	+1 / +2	+1 / +1	+1 / +1							
		SUPPORT FACILITIES	36																				
	TRANSPORTATION	MINE PRODUCTS	37																			-1 / -1	
		WASHING/BENEFICIATION PRODUCTS	38																				
		SULFURIC ACID PLANT PRODUCTS	39																				
		PHOSPHATE PLANT PRODUCTS	40																				
		WATER	41																				
		PEOPLE	42																				
		SUPPORT PRODUCTS	43																				
SECONDARY ACTIVITIES	SUPPORT ACTIVITIES	MINING	44	-1 / -2		-1 / -2	0 / -1				0 / -2	0 / -1	0 / -1	0 / -2	-1 / -2	-1 / -2						-1 / -1	
		WASHING/BENEFICIATION	45	-1 / -2		-1 / -2	0 / -1				0 / -2	0 / -1	0 / -1	0 / -2	-1 / -2	-1 / -2							
		PROCESSING	46	-1 / -2		-1 / -2	0 / -1				0 / -2	0 / -1	0 / -1	0 / -2	-1 / -2	-1 / -2							
		RECLAMATION	47																				
		TRANSPORTATION	48			-1 / -1									-1 / -1	-1 / -1							
		LAND ACQUISITION	49																				
		RESEARCH AND DEVELOPMENT	50																				
		GOVERNMENT AND PUBLIC RELATIONS	51																				

E

-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1

$\frac{-7}{-7}$

$\frac{-1}{-1}$

$\frac{-3}{0}$

$\frac{-1}{-1}$ $\frac{-1}{-1}$

$\frac{-1}{-1}$ $\frac{-1}{-1}$

$\frac{-1}{-1}$ $\frac{-1}{-1}$

$\frac{0}{-1}$

$\frac{-1}{-1}$ $\frac{-1}{-1}$

-4	-2	-1	-1	-2	-1	-4
-6	-4	-1	-1	-6	-1	-8
-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1

$\frac{-1}{-1}$ $\frac{-1}{-1}$

$\frac{-1}{-1}$ $\frac{-1}{-1}$

F

G

H

A

ENVIRONMENTAL EFFECTS MATRIX FOR CENTRAL FLORIDA PHOSPHATE INDUSTRY

SCENARIO

PLATE 5 - Volume VII

REQUIRE PROCESS MODIFICATIONS

NATI

					AQUATIC BIOTA													TERRESTRIAL BIOTA							
									STANDING WATERS			RUNNING WATERS			BAYS AND ESTUARIES							UPLANDS			W
					THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	RESOURCE POTENTIAL	HABITAT QUALITY	COMMUNITY STRUCTURE	FLOW REGIME	HABITAT QUALITY	COMMUNITY STRUCTURE	FRESHWATER DISCHARGE PATTERNS	HABITAT QUALITY	COMMUNITY STRUCTURE	THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE	AREAL EXTENT
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	2
ACTIVITIES	EXPLORATION/MINING	DRILLING	PROSPECT DRILLING	1																					
			WATER WELL DRILLING	2																					
		LAND PREPARATION	DRAINING/DEWATERING	3	-1		-1	+1	-1	-1	-1	-1	-1	-1									-1	-1	
					-2		-1	+2	-2	-2	-2	-1	-1	-1									-1	-1	
			CLEARING	4	-1		-2			-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-
					-1		-2			-2	-2	-2	-2	-2	-1	-2	-1	-1	-1	-1	-1	-1	-1	-1	-
			BURNING	5																					
		LAND EXCAVATION	DRAGLINING	6	-2		-	+1	-1	-1	-1	-1	-1	-1	0			-4	-4	-1	-1	-4	-1	-4	-
					-2		-1	+1	-2	-2	-2	-1	-1	-1	-1			-8	-6	-1	-1	-8	-1	-6	-
			DREDGING	7	-1		-1	+1	-1	-1	-1	-1	-1	-1	0										
					-2		-1	+1	-2	-2	-2	-1	-1	-1	-1										
			OVERBURDEN PLACEMENT	8																					
			WATER EXTRACTION	9																					
			WATER INJECTION	10																					
			EQUIPMENT RELOCATION	11																					
	WASHING/ BENEFICIATION		PRODUCT STORAGE	12																					
			PRODUCT DRYING	13																					
			TAILINGS PLACEMENT	14																					
			SLIME PLACEMENT	15	-2		-2	-1		-2	-2	-1	-2	-2	-1	-2	-2	-1	-1	-1	-1	-1	-1	-1	-
					-4		-4	-2		-4	-4	-2	-4	-4	-2	-4	-4	-1	-1	-1	-1	-1	-1	-1	-
			WATER USE/RECYCLE	16	0		0	-1	+1			+1	+1	+1	+1	+1	+1								
					-1		-1	-1	+2			+1	+1	+1	+1	+1	+1								
CESSING		MANUFACTURING	SULFURIC ACID	17			-1			-1	-1		-1	-1		-1	-1						-1		
							-1			-1	-1		-1	-1		-1	-1						-1		
			FERTILIZER PRODUCTS	18			-1			-1	-1		-1	-1		-1	-1								
							-1			-1	-1		-1	-1		-1	-1								
			ANIMAL GRADE PHOSPHATE	19			-1			-1	-1		-1	-1		-1	-1								
							-1			-1	-1		-1	-1		-1	-1								
			ELEMENTAL PHOSPHORUS	20																					

NOLOGICAL DEMAND ELEMENTS

B

ENVIRON

NATURAL RESOURCES

AQUATIC BIOTA											TERRESTRIAL BIOTA										PHYSICAL AND HYDROLOGICAL ELEM													
		STANDING WATERS			RUNNING WATERS			BAYS AND ESTUARIES							UPLANDS			WETLANDS			LAND						SURFACE WATER		SUBSURFACE WATER				HYDR PRO	
																													WATER TABLE		FLORIDAN AQUIFER			
COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	RESOURCE POTENTIAL	HABITAT QUALITY	COMMUNITY STRUCTURE	FLOW REGIME	HABITAT QUALITY	COMMUNITY STRUCTURE	FRESHWATER DISCHARGE PATTERNS	HABITAT QUALITY	COMMUNITY STRUCTURE	THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE	MINERAL RESOURCES	UNIQUE PHYSICAL FEATURES	SOILS	EXPOSURE	TOPOGRAPHY	BACKGROUND RADIATION	QUALITY	QUANTITY	QUALITY	QUANTITY	QUALITY	QUANTITY	AQUIFER RECHARGE	EROSION
3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
-1	+1	-1	-1	-1	-1	-1	-1									-1	-1		-1	-1														
-1	+2	-2	-2	-2	-1	-1	-1									-1	-1		-1	-1														
-2			-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0						-5							
-2			-2	-2	-2	-2	-2	-1	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1						-5							
																											-5							
																											-5							
-1	+1	-1	-1	-1	-1	-1	-1	0			-4	-4	-1	-1	-4	-1	-4	-10	-1	-4	-1													
-1	+1	-2	-2	-2	-1	-1	-1	-1			-8	-6	-1	-1	-8	-1	-6	-10	-1	-8	-3													
-1	+1	-1	-1	-1	-1	-1	-1	0																						+1				
-1	+1	-2	-2	-2	-1	-1	-1	-1																						0				
																			-1													-3		
																			-1													0		
-2	-1		-2	-2	-1	-2	-2	-1	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1							-7		0					
-4	-2		-4	-4	-2	-4	-4	-2	-4	-4	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1							-7		-1					
-0	-1	+1			+1	+1	+1	+1	+1	+1																					-1			
-1	-1	+2			+1	+1	+1	+1	+1	+1																					-1			
-1			-1	-1		-1	-1		-1	-1						-1			-1													-3		
-1			-1	-1		-1	-1		-1	-1						-1			-1													0		
-1			-1	-1		-1	-1		-1	-1																								
-1			-1	-1		-1	-1		-1	-1																								
-1			-1	-1		-1	-1		-1	-1																								
-1			-1	-1		-1	-1		-1	-1																								

C

MENTAL DEMAND ELEMENTS

				SOCIAL RESOURCES																													
TS				ANXIETY FACTORS							COMMUNITY							MAN-MADE (OR MAN-ORIENTED)							LAND TENURE		LAND USE					
LOGICAL ESSES		ATMOSPHERE																					RECREATION										
FLOODING	CAVITATION	CLIMATE/WEATHER	AIR QUALITY	AIR	WATER	RADIATION	NOISE	PERSONAL PROPERTY	UTILITIES	VISUAL DEGRADATION	COHESION	SPATIAL GROWTH	DENSITY	DIVERSITY	ACCESSIBILITY OF FACILITIES AND SERVICES	DISPLACEMENT	MOBILITY	TRANSPORTATION	HOUSING	CULTURAL OPPORTUNITIES	AESTHETICS	ARCHEOLOGICAL AND HISTORICAL SITES	WATER BASED	LAND BASED	PUBLIC LAND	PRIVATE LAND	REGIONAL AND COMMUNITY PLANS	RESIDENTIAL DEVELOPMENT	COMMERCIAL DEVELOPMENT	INDUSTRIAL DEVELOPMENT	MINING	FORESTS
38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	7
																							-1										
																							-1										
																						-1	-1	-3							+6	-
																						-3	-3	-5							+10	-
																						-1	-1								+1	-
																						-1	-1								+1	-
																						-10								+1	+6	
																						-10								+3	+10	
																						-1										
										-3																						
																							-1				-1	-1			+1	
																							-1				-1	-1			+3	
																						-1										
										-1																						
										0																	-1	-1				
																											-1	-1				
																						-1		0								
																						-3		+3								
				-1	-1	-1					0	0			0	0	-1				-5											
				-2	-2	-2					-5	-5			-5	-5	-3				-5											
																														+1		
																														+3		
																														+1		-
																														+3		-
																														+1		
																														+3		

ENTRIES IN LINE 16 ACCOUNT FOR ALL IMPACTS FROM LINES 1 THROUGH 16

D

															ECONOMIC RESOURCES																		
D)		LAND TENURE		LAND USE													LOCAL		PUBLIC FACILITIES AND SERVICES							LOCAL/ REGIONAL ACTIVITY								
REATION																																	
	LAND BASED	PUBLIC LAND	PRIVATE LAND	REGIONAL AND COMMUNITY PLANS	RESIDENTIAL DEVELOPMENT	COMMERCIAL DEVELOPMENT	INDUSTRIAL DEVELOPMENT	MINING	FORESTS	AGRICULTURE	OPEN SPACE	NATIONAL ECONOMIC DEVELOPMENT	STATE ECONOMIC DEVELOPMENT	TAX REVENUE	PROPERTY VALUES	EDUCATIONAL	HEALTH	FIRE/POLICE PROTECTION	WATER SUPPLY	ELECTRICAL SERVICE	WASTE TREATMENT AND DISPOSAL	STREETS AND ROADS	TRENDS IN LOCAL ECONOMIC DEVELOPMENT	TRENDS IN REGIONAL ECONOMIC DEVELOPMENT	EMPLOYMENT/LABOR FORCE	AGRICULTURAL ACTIVITY	BUSINESS AND INDUSTRIAL ACTIVITY – MAJOR ECONOMIC, NON-PHOSPHATE	ECONOMIC GEOLOGIC RESOURCES	BALANCE OF TRADE	NATIONAL DEFENSE OR SELF SUFFICIENCY
	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
	-3							+6	-4	-2	0																			
	-5							+10	-8	-4	-5																			
								+1	-1		-1																			
								+1	-1		-1																			
							+1	+6																						
							+3	+10																						
				-1	-1			+1																						
				-1	-1			+3																						
				-1	-1					-1																				
				-1	-1					-1																				
	0									0																				
	+3									+3																				
												0	0	0									0	0	+5	0	+5	-5	+2	0
												+5	+5	+5									+5	+5	+5	+5	+5	+5	+5	+5
							+1																							
							+3																							
							+1		-1																					
							+3		-1																					
							+1																							

ENTRIES IN LINE 16 ACCOUNT FOR ALL IMPACTS FROM LINES 1 THROUGH 16

TECHNOLOGICAL DEMA

PRIMARY ACTIVITIES	WASI BENEFI	SLIME PLACEMENT	15	-2		-2	-1		-2	-2	-1	-2	-2	-1	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1
				-4		-4	-2		-4	-4	-2	-4	-4	-2	-4	-4	-1	-1	-1	-1	-1	-1	-1	-1
		WATER USE/RECYCLE	16	0		0	-1	+1			+1	+1	+1	+1	+1	+1								
				-1		-1	-1	+2			+1	+1	+1	+1	+1	+1								
	PROCESSING / MANUFACTURING	SULFURIC ACID	17			-1			-1	-1		-1	-1		-1	-1							-1	
						-1			-1	-1		-1	-1		-1	-1							-1	
		FERTILIZER PRODUCTS	18			-1			-1	-1		-1	-1		-1	-1								
						-1			-1	-1		-1	-1		-1	-1								
		ANIMAL GRADE PHOSPHATE	19			-1			-1	-1		-1	-1		-1	-1								
						-1			-1	-1		-1	-1		-1	-1								
		ELEMENTAL PHOSPHORUS	20																					
		WASTE TREATMENT	21																					
		WASTE PLACEMENT	22	+1		+1	-1		-1	-1	+1	+1	+1		+2	+2								
				+2		+2	-2		-1	-1	+1	+1	+1		+2	+2								
		WATER USE/RECYCLE	23	+1		+1	-1	+1			+1	+1	+1	+1	+1	+1								
				+1		+1	-2	+2			+1	+1	+1	+1	+1	+1								
	CONSTRUCTION	DAMS AND LEVEES	24	-1		-1	-1	+1	-1	-1	-1	-1	-1	-1	-1	-1							-1	
				-1		-1	-2	+2	-2	-2	-2	-2	-2	-2	-1	-1							-1	
		TRANSPORTATION LINES	25																					
		UTILITY LINES	26																					
		WASHING/BENEFICIATION PLANTS	27																					
		PROCESSING PLANTS	28																					
		DRAINAGE SYSTEMS	29	-1		-1	+1	-1	-1	-1	-1	-1	-1	-1	-1	-1							-1	
				-1		-2	+2	-2	-2	-2	-2	-2	-2	-2	-1	-1							-1	
	RECLAMATION	TRANSPORTATION SYSTEMS	30																					
		MINING PITS	31	+1		+2	-1	+2			-2	-1	-1	-1	-1	-1	-4	-2	-1	-1	-2	-1		
				+2		+4	-2	+4			-4	-2	-2	-2	-2	-2	-6	-4	-1	-1	-6	-1		
		SLIME PONDS	32	+2		+2	+1		+2	+2	+1	+2	+2	+1	+2	+2	-1	-1	-1	-1	-1	-1		
				+4		+4	+2		+4	+4	+2	+4	+4	+2	+4	+4	-1	-1	-1	-1	-1	-1		
		UTILITY SYSTEMS	33																					
		PLANT SITES	34																					
		DAMS AND LEVEES	35	+1		+1	+1	-1	+1	+1	+1	+1	+1	+1	+1	+1								
				+1		+1	+2	-2	+2	+2	+2	+2	+2	+2	+1	+1								
		SUPPORT FACILITIES	36																					
	TRANSPORTATION	MINE PRODUCTS	37																				-1	
																							-1	
		WASHING/BENEFICIATION PRODUCTS	38																					
		SULFURIC ACID PLANT PRODUCTS	39																					
		PHOSPHATE PLANT PRODUCTS	40																					
		WATER	41																					
		PEOPLE	42																					
		SUPPORT PRODUCTS	43																					
SECONDARY ACTIVITIES	SUPPORT ACTIVITIES	MINING	44	-1		-1	0				0	0	0	0	-1	-1							-1	
				-2		-2	-1				-2	-1	-1	-2	-2	-2							-1	
		WASHING/BENEFICIATION	45	-1		-1	0				0	0	0	0	-1	-1								
				-2		-2	-1				-2	-1	-1	-2	-2	-2								
		PROCESSING	46	-1		-1	0				0	0	0	0	-1	-1								
				-2		-2	-1				-2	-1	-1	-2	-2	-2								
		RECLAMATION	47																					
		TRANSPORTATION	48			-1									-1	-1								
						-1									-1	-1								
		LAND ACQUISITION	49																					
		RESEARCH AND DEVELOPMENT	50																					
		GOVERNMENT AND PUBLIC RELATIONS	51																					

E

-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1

-7	0
-7	-1

-1
-1

IMPACTS FROM

-1	-1	-1
-2	-2	-2

-1	-1
-1	-1

-3
0

+1	+1	+1
+1	+1	+1
		+1
		+1

-1	-1
-1	-1

0
-1

-1	-1
-1	-1

-1	-1	-2	-1	-4
-1	-1	-6	-1	-8
-1	-1	-1	-1	-1
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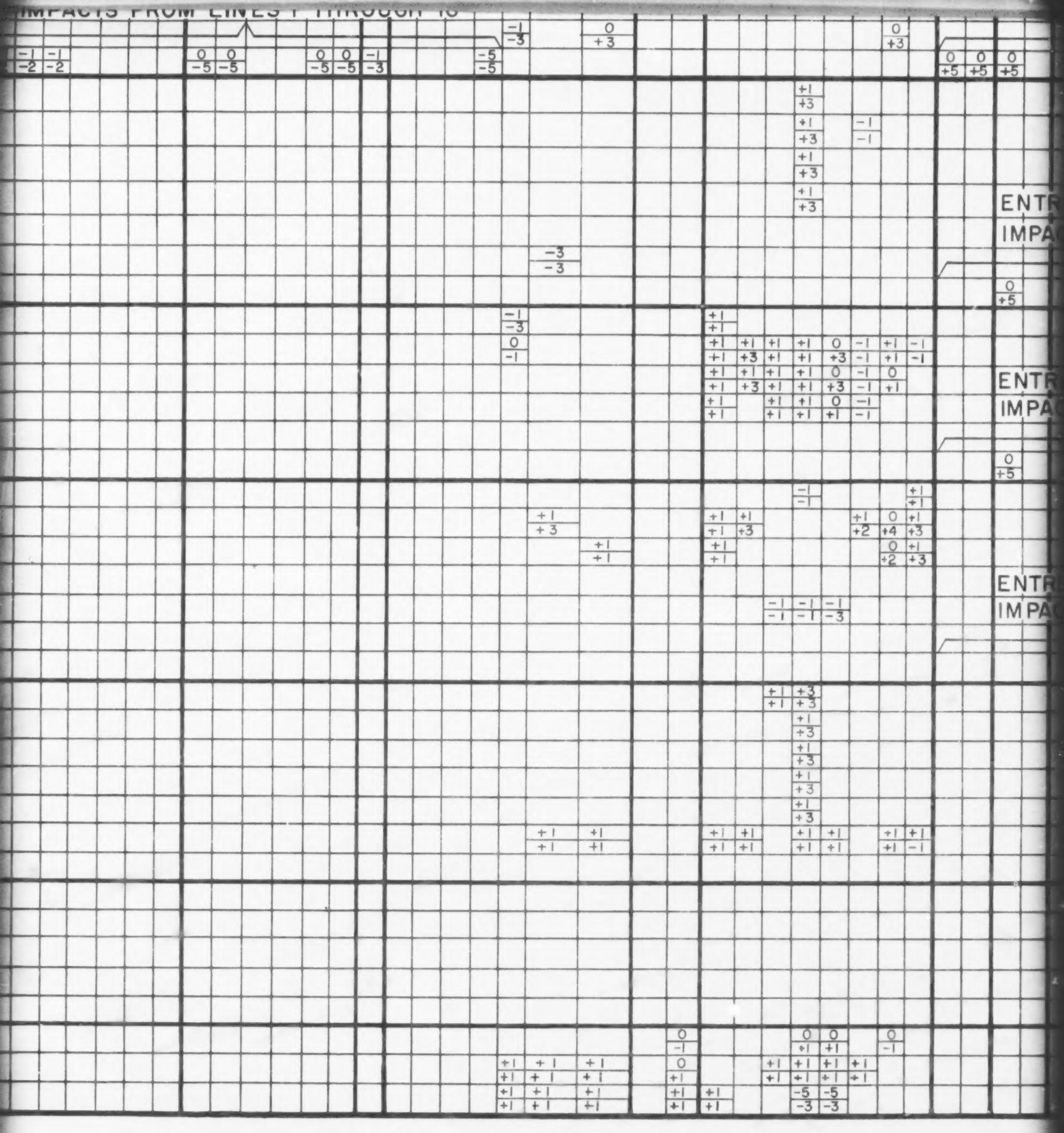
IMPACTS FROM LINES 1 THROUGH 18
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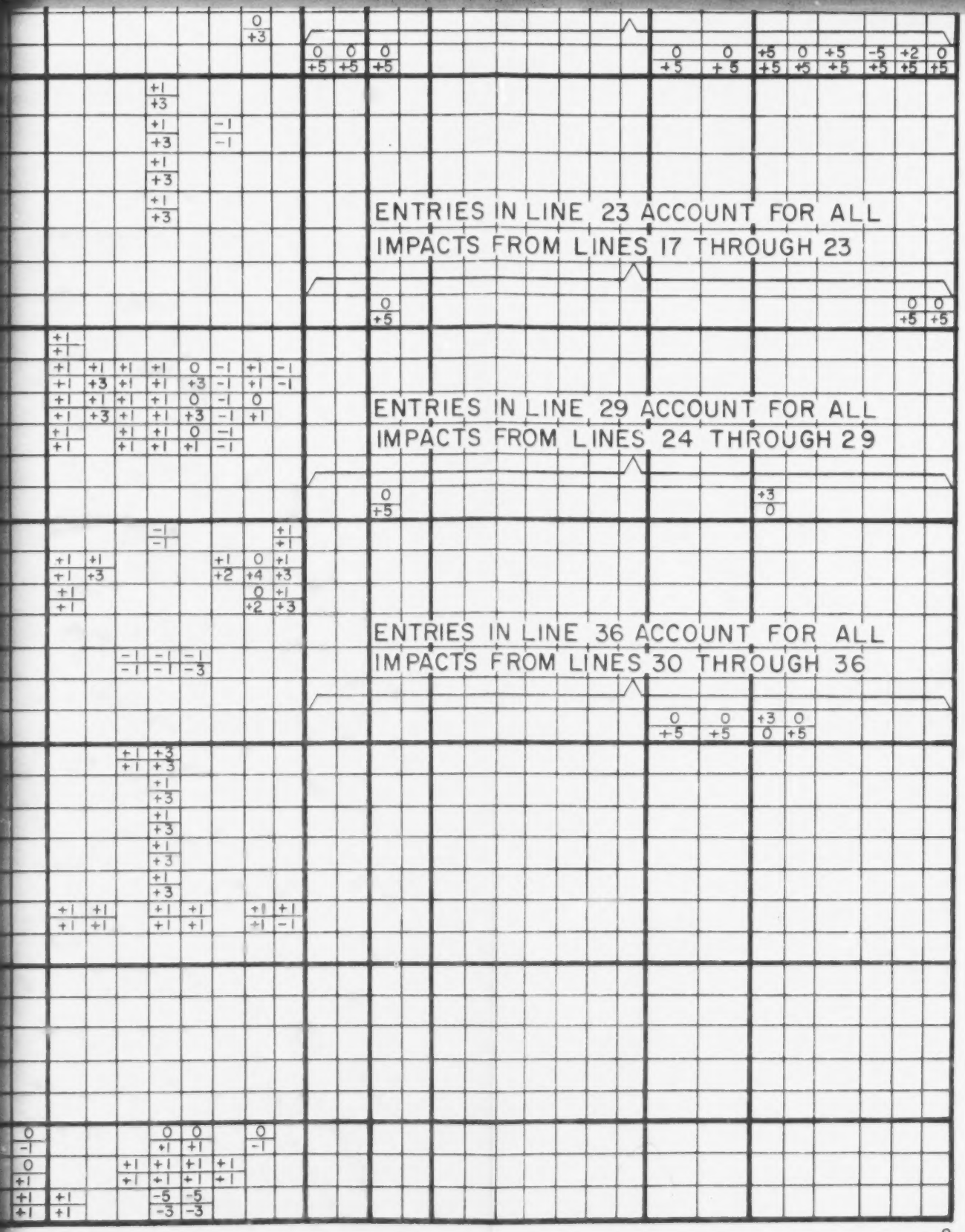
ENTRIES IN LINE 23 ACCOUNT FOR ALL IMPACTS FROM LINES 17 THROUGH 23
ENTRIES IN LINE 29 ACCOUNT FOR ALL IMPACTS FROM LINES 24 THROUGH 29
ENTRIES IN LINE 36 ACCOUNT FOR ALL IMPACTS FROM LINES 30 THROUGH 36

H

A

ENVIRONMENTAL EFFECTS MATRIX FOR CENTRAL FLORIDA PHOSPHATE INDUSTRY

SCENARIO
PLATE 6 - Volume VII

REQUIRE REDUCED WATER USAGES

NAT

				AQUATIC BIOTA													TERRESTRIAL BIOT						
								STANDING WATERS			RUNNING WATERS			BAYS AND ESTUARIES							UPLANDS		
				THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	RESOURCE POTENTIAL	HABITAT QUALITY	COMMUNITY STRUCTURE	FLOW REGIME	HABITAT QUALITY	COMMUNITY STRUCTURE	FRESHWATER DISCHARGE PATTERNS	HABITAT QUALITY	COMMUNITY STRUCTURE	THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
EXPLORATION/MINING	DRILLING	PROSPECT DRILLING	1																				
		WATER WELL DRILLING	2																				
	LAND PREPARATION	DRAINING/DEWATERING	3	-1		-1	+1	-1	-1	-1	-1	-1	-1									-1	-1
				-2		-1	+2	-2	-2	-2	-1	-1	-1									-1	-1
		CLEARING	4	-1		-2			-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
				-1		-2			-2	-2	-2	-2	-2	-1	-2	-1	-1	-1	-1	-1	-1	-1	-1
		BURNING	5																				
	LAND EXCAVATION	DRAGLINING	6	-2		-1	+1	-1	-1	-1	-1	-1	-1	0			-4	-4	-1	-1	-4	-1	-4
				-2		-1	+1	-2	-2	-2	-1	-1	-1	-1			-8	-6	-1	-1	-8	-1	-6
		DREDGING	7	-1		-1	+1	-1	-1	-1	-1	-1	-1	0									
				-2		-1	+1	-2	-2	-2	-1	-1	-1	-1									
	OVERBURDEN PLACEMENT		8																				
	WATER EXTRACTION		9																				
	WATER INJECTION		10																				
	EQUIPMENT RELOCATION		11																				
WASHING/ BENEFICIATION	PRODUCT STORAGE		12																				
	PRODUCT DRYING		13																		-1		
																					-1		
	TAILINGS PLACEMENT		14																				
	SLIME PLACEMENT		15	-2		-2	-1		-2	-2	-1	-2	-2	-1	-2	-2	-1	-1	-1	-1	-1	-1	-1
				-4		-4	-2		-4	-4	-2	-4	-4	-2	-4	-4	-1	-1	-1	-1	-1	-1	-1
	WATER USE/RECYCLE		16	0		0	-1	+1			+1	+1	+1	+1	+1	+1							
				-1		-1	-1	+2			+1	+1	+1	+1	+1	+1							
ING	UFACTURING	SULFURIC ACID	17			-1			-1	-1		-1	-1		-1	-1						-1	
						-1			-1	-1		-1	-1		-1	-1						-1	
		FERTILIZER PRODUCTS	18			-1			-1	-1		-1	-1		-1	-1							
						-1			-1	-1		-1	-1		-1	-1							
		ANIMAL GRADE PHOSPHATE	19			-1			-1	-1		-1	-1		-1	-1							
						-1			-1	-1		-1	-1		-1	-1							

LOGICAL DEMAND ELEMENTS

TIVITIES

B

ENVIRONMENTAL DEMAND ELEMENTS

NATURAL RESOURCES: TERRESTRIAL BIOTA (13–23: UPLANDS 18–20, WETLANDS 21–23); PHYSICAL AND HYDROLOGICAL ELEMENTS (24–41: LAND 24–29; SURFACE WATER 30–31; SUBSURFACE WATER 32–35 – WATER TABLE 32–33, FLORIDAN AQUIFER 34–35; HYDROLOGICAL PROCESSES 36–39; ATMOSPHERE 40–41); ANXIETY FA[CTORS] (42–45)

COMMUNITY STRUCTURE 13	THREATENED AND ENDANGERED SPECIES 14	ECOLOGICALLY SIGNIFICANT SPECIES 15	COMMERCIAL AND RECREATIONAL SPECIES 16	NUISANCE AND PEST SPECIES 17	AREAL EXTENT 18	HABITAT QUALITY 19	COMMUNITY STRUCTURE 20	AREAL EXTENT 21	HABITAT QUALITY 22	COMMUNITY STRUCTURE 23	MINERAL RESOURCES 24	UNIQUE PHYSICAL FEATURES 25	SOILS 26	EXPOSURE 27	TOPOGRAPHY 28	BACKGROUND RADIATION 29	QUALITY 30	QUANTITY 31	QUALITY 32	QUANTITY 33	QUALITY 34	QUANTITY 35	AQUIFER RECHARGE 36	EROSION 37	FLOODING 38	CAVITATION 39	CLIMATE/WEATHER 40	AIR QUALITY 41	AIR 42	WATER 43	RADIATION 44	NOISE 45
						-1	-1		-1	-1																						
						-1	-1		-1	-1																						
	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0						-5															
	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1						-5															
																	-5															
																	-5															
	-4	-4	-1	-1	-4	-1	-4	-10	-1	-4	-1																					
	-8	-6	-1	-1	-8	-1	-6	-10	-1	-8	[illegible]																					
																				+1												
																				0												
									-1									-5		+3		-3										
									-1									-5		0		0										
																												0				
																												-1				
					-1				-1																			0				
					-1				-1																			-1				
	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1							-7															
	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1							-7															
																					-1								-1	-1	-1	
																					-1								-2	-2	-2	
						-1			-1									-5		+3		-3										
						-1			-1									-5		0		0										

ENTRIES

IMPACTS

ENVIRONMENTAL DEMAND ELEMENTS C

[...]ND HYDROLOGICAL ELEMENTS: SUBSURFACE WATER (WATER TABLE: 32–33; FLORIDAN AQUIFER: 34–35); HYDROLOGICAL PROCESSES (36–39); ATMOSPHERE (40–41)

SOCIAL RESOURCES: ANXIETY FACTORS (42–48); COMMUNITY (49–54); 55; MAN-MADE (OR MAN-ORIENTED) (56–62, RECREATION: 61–62); [...] (63)

QUALITY 32	QUANTITY 33	QUALITY 34	QUANTITY 35	AQUIFER RECHARGE 36	EROSION 37	FLOODING 38	CAVITATION 39	CLIMATE/WEATHER 40	AIR QUALITY 41	AIR 42	WATER 43	RADIATION 44	NOISE 45	PERSONAL PROPERTY 46	UTILITIES 47	VISUAL DEGRADATION 48	COHESION 49	SPATIAL GROWTH 50	DENSITY 51	DIVERSITY 52	ACCESSIBILITY OF FACILITIES AND SERVICES 53	DISPLACEMENT 54	MOBILITY 55	TRANSPORTATION 56	HOUSING 57	CULTURAL OPPORTUNITIES 58	AESTHETICS 59	ARCHEOLOGICAL AND HISTORICAL SITES 60	WATER BASED 61	LAND BASED 62	PUBLIC LAND 63
																													-1/-1		
																												-1/-3	-1/-3	-3/-5	
																												-1/-1	-1/-1		
																												-10			
																												-10			
	+1/0																														
																												-1/-3			
	+3/0		-3/0																										-1/-1		
																												-1/-1			
									0/-1/0/-1																						
		-1/-1								-1/-2	-1/-2	-1/-2					0/-5	0/-5			0/-5	0/-5	-1/-3				-5/-5	-1/-3			
	+3/0		-3/0																												

ENTRIES IN LINE 16 ACCOUNT FOR ALL IMPACTS FROM LINES 1 THROUGH 16

D

RCES													ECONOMIC RESOURCES																		
ADE ORIENTED)			LAND TENURE		LAND USE										LOCAL		PUBLIC FACILITIES AND SERVICE							LOCAL/ REGIONAL ACTIVITY							
	RECREATION																														
ARCHEOLOGICAL AND HISTORICAL SITES	WATER BASED	LAND BASED	PUBLIC LAND	PRIVATE LAND	REGIONAL AND COMMUNITY PLANS	RESIDENTIAL DEVELOPMENT	COMMERCIAL DEVELOPMENT	INDUSTRIAL DEVELOPMENT	MINING	FORESTS	AGRICULTURE	OPEN SPACE	NATIONAL ECONOMIC DEVELOPMENT	STATE ECONOMIC DEVELOPMENT	TAX REVENUE	PROPERTY VALUES	EDUCATIONAL	HEALTH	FIRE/POLICE PROTECTION	WATER SUPPLY	ELECTRICAL SERVICE	WASTE TREATMENT AND DISPOSAL	STREETS AND ROADS	TRENDS IN LOCAL ECONOMIC DEVELOPMENT	TRENDS IN REGIONAL ECONOMIC DEVELOPMENT	EMPLOYMENT/LABOR FORCE	AGRICULTURAL ACTIVITY	BUSINESS AND INDUSTRIAL ACTIVITY – MAJOR ECONOMIC, NON-PHOSPHATE	ECONOMIC GEOLOGIC RESOURCES	BALANCE OF TRADE	NATIONAL DEFENSE OR SELF SUFFICIENCY
60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
	-1																														
	-1																														
-1	-1	-3							+6	-4	-2	0																			
-3	-3	-5							+10	-8	-4	-5																			
-1	-1								+1	-1		-1																			
-1	-1								+1	-1		-1																			
-10								+1	+6																						
-10								+3	+10																						
-1																															
-3																															
	-1				-1	-1			+1																						
	-1				-1	-1			+3																						
-1																															
-1																															
					-1	-1					-1																				
					-1	-1					-1																				
-1																															
-3																															
													0	0	0									0	0	+5	0	+5	-5	+2	0
													+5	+5	+5									+5	[illegible]	+5	+5	+5	+5	+5	+5
								+1																							
								+3																							
								+1		-1																					
								+3		-1																					
								+1																							
								+3																							

ENTRIES IN LINE 16 ACCOUNT FOR ALL IMPACTS FROM LINES 1 THROUGH 16

PRIMARY ACTIVITIES	WAS BENEF	SLIME PLACEMENT	15	-2		-2	-1		-2	-2	-1	-2	-2	-1	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
				-4		-4	-2		-4	-4	-2	-4	-4	-2	-4	-4	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
		WATER USE/RECYCLE	16	0		0	-1	+1			+1	+1	+1	+1	+1	+1										
				-1		-1	-1	+2			+1	+1	+1	+1	+1	+1										
	PROCESSING / MANUFACTURING	SULFURIC ACID	17			-1			-1	-1		-1	-1		-1	-1							-1			-1
						-1			-1	-1		-1	-1		-1	-1							-1			-1
		FERTILIZER PRODUCTS	18			-1			-1	-1		-1	-1		-1	-1										
						-1			-1	-1		-1	-1		-1	-1										
		ANIMAL GRADE PHOSPHATE	19			-1			-1	-1		-1	-1		-1	-1										
						-1			-1	-1		-1	-1		-1	-1										
		ELEMENTAL PHOSPHORUS	20																							
		WASTE TREATMENT	21																							
		WASTE PLACEMENT	22	+1		+1	-1		-1	-1	+1	+1	+1		+2	+2							-1			-
				+2		+2	-2		-1	-1	+1	+1	+1		+2	+2							-1			-
		WATER USE/RECYCLE	23	+1		+1	-1	+1			+1	+1	+1	+1	+1	+1										
				+1		+1	-2	+2			+1	+1	+1	+1	+1	+1										
	CONSTRUCTION	DAMS AND LEVEES	24	-1		-1	-1	+1	-1	-1	-1	-1	-1	-1	-1	-1							-1			-
				-1		-1	-2	+2	-2	-2	-2	-2	-2	-2	-1	-1							-1			-
		TRANSPORTATION LINES	25																							
		UTILITY LINES	26																							
		WASHING/BENEFICIATION PLANTS	27																							
		PROCESSING PLANTS	28																							
		DRAINAGE SYSTEMS	29	-1		-1	+1	-1	-1	-1	-1	-1	-1	-1	-1	-1							-1			-
				-1		-2	+2	-2	-2	-2	-2	-2	-2	-2	-1	-1							-1			-
	RECLAMATION	TRANSPORTATION SYSTEMS	30																							
		MINING PITS	31	+1		+2	-1	+2			-2	-1	-1	-1	-1	-1	-4	-2	-1	-1	-2	-1	-4			
				+2		+4	-2	+4			-4	-2	-2	-2	-2	-2	-6	-4	-1	-1	-6	-1	-8			
		SLIME PONDS	32	+2		+2	+1		+2	+2	+1	+2	+2	+1	+2	+2	-1	-1	-1	-1	-1	-1	-1			
				+4		+4	+2		+4	+4	+2	+4	+4	+2	+4	+4	-1	-1	-1	-1	-1	-1	-1			
		UTILITY SYSTEMS	33																							
		PLANT SITES	34																							
		DAMS AND LEVEES	35	+1		+1	+1	-1	+1	+1	+1	+1	+1	+1	+1	+1										
				+1		+1	+2	-2	+2	+2	+2	+2	+2	+2	+1	+1										
		SUPPORT FACILITIES	36																							
	TRANSPORTATION	MINE PRODUCTS	37																				-1			-
																							-1			-
		WASHING/BENEFICIATION PRODUCTS	38																							
		SULFURIC ACID PLANT PRODUCTS	39																							
		PHOSPHATE PLANT PRODUCTS	40																							
		WATER	41																							
		PEOPLE	42																							
		SUPPORT PRODUCTS	43																							
SECONDARY ACTIVITIES	SUPPORT ACTIVITIES	MINING	44	-1		-1	0				0	0	0	0	-1	-1							-1			-
				-2		-2	-1				-2	-1	-1	-2	-2	-2							-1			-
		WASHING/BENEFICIATION	45	-1		-1	0				0	0	0	0	-1	-1										
				-2		-2	-1				-2	-1	-1	-2	-2	-2										
		PROCESSING	46	-1		-1	0				0	0	0	0	-1	-1										
				-2		-2	-1				-2	-1	-1	-2	-2	-2										
		RECLAMATION	47																							
		TRANSPORTATION	48			-1									-1	-1										
						-1									-1	-1										
		LAND ACQUISITION	49																							
		RESEARCH AND DEVELOPMENT	50																							
		GOVERNMENT AND PUBLIC RELATIONS	51																							

E

-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1

-7
-7

-1
-1

-1	-1	-1
-2	-2	-2

-1	-1
-1	-1

-5	+3	-3
-5	0	0

-1	-1
-1	-1

-1	-1
-1	-1

0
-1

-1	-1
-1	-1

-1	-1	-2	-1	-4
-1	-1	-6	-1	-8
-1	-1	-1	-1	-1
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-1	-1
-1	-1

-1	-1
-1	-1

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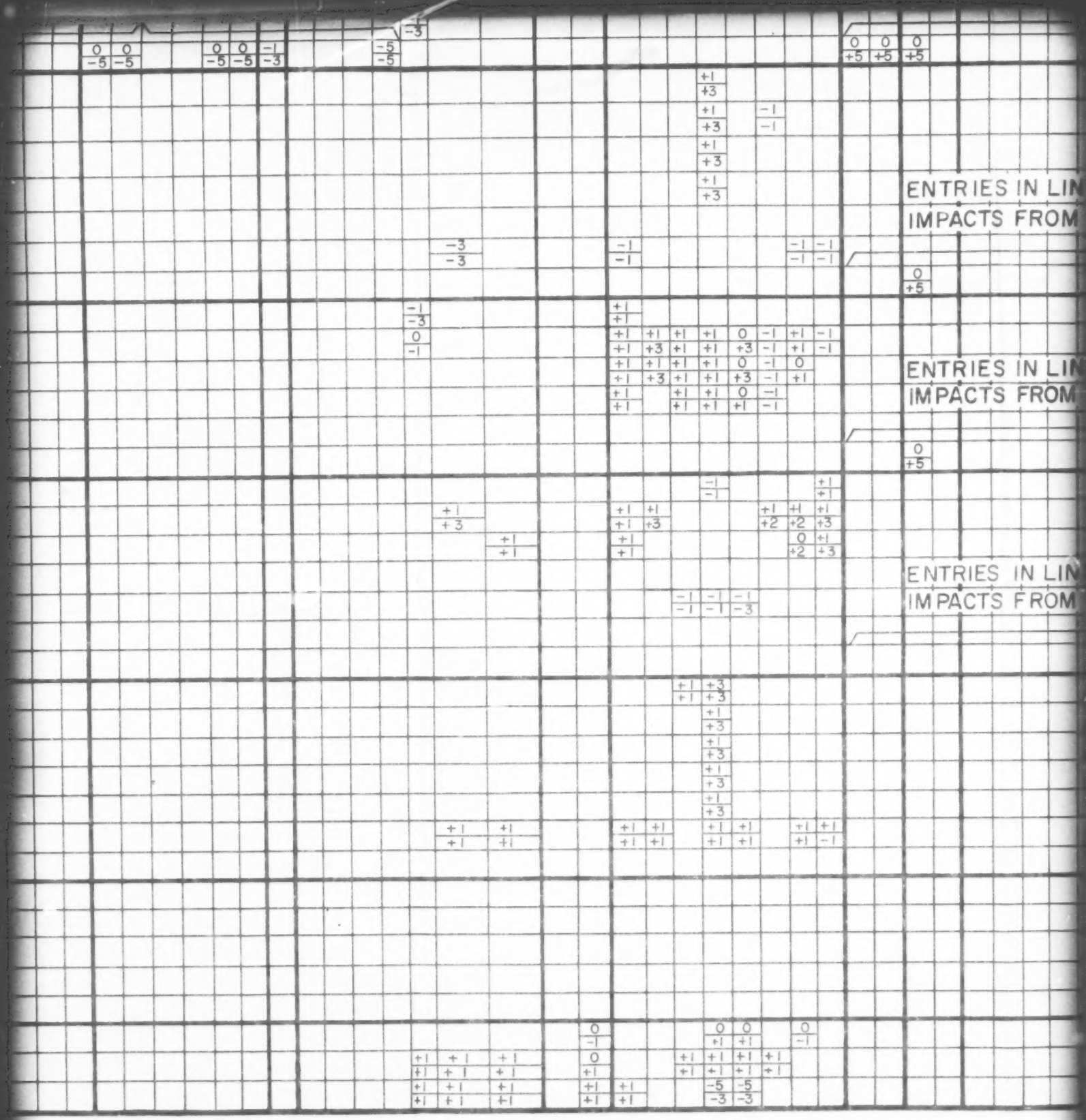
ENTRIES IN LIN
IMPACTS FROM
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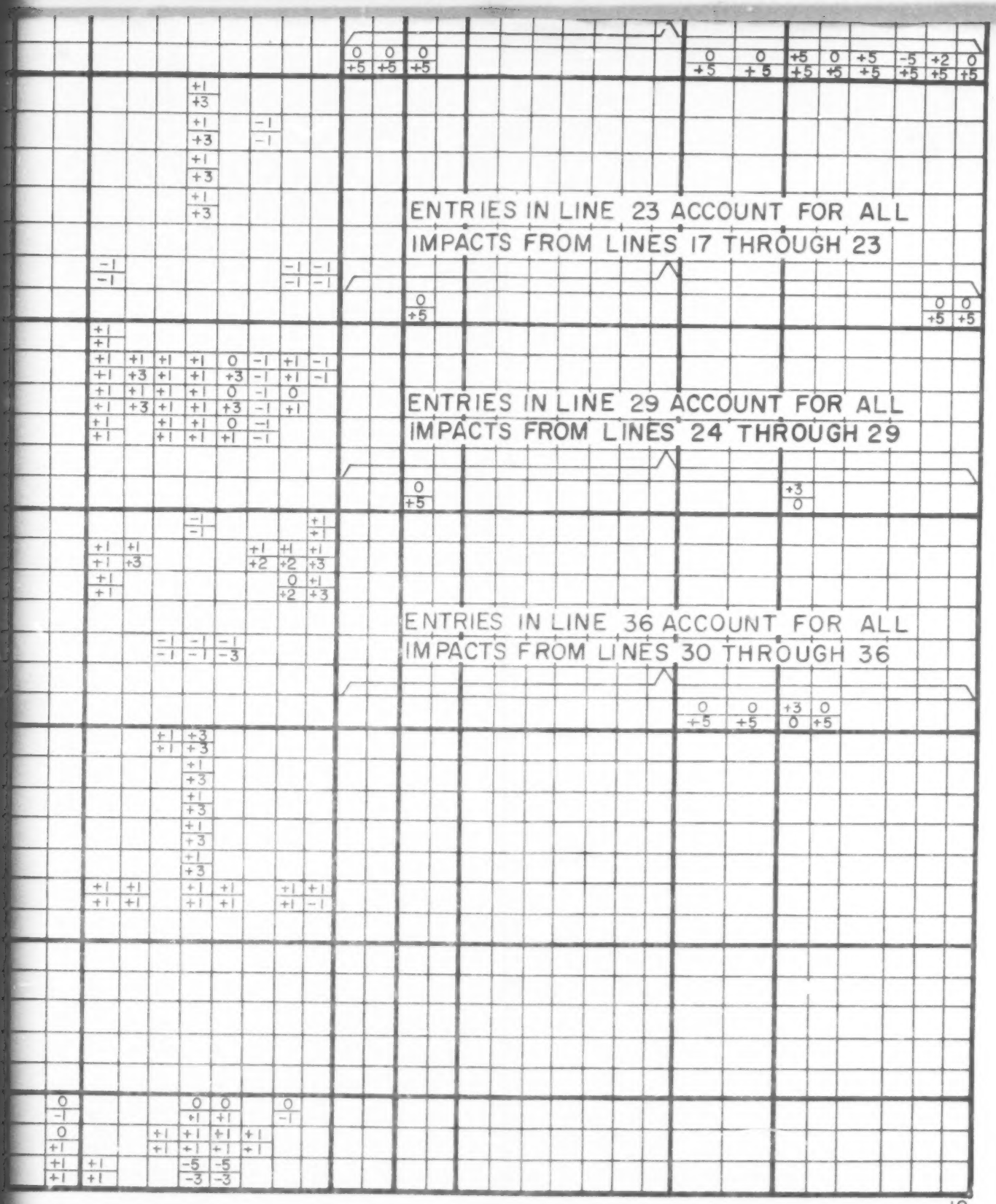

ENTRIES IN LINE 23 ACCOUNT FOR ALL IMPACTS FROM LINES 17 THROUGH 23
ENTRIES IN LINE 29 ACCOUNT FOR ALL IMPACTS FROM LINES 24 THROUGH 29
ENTRIES IN LINE 36 ACCOUNT FOR ALL IMPACTS FROM LINES 30 THROUGH 36

H

A

ENVIRONMENTAL EFFECTS MATRIX FOR CENTRAL FLORIDA PHOSPHATE INDUSTRY

SCENARIO

PLATE 7 - Volume VII

CONTROL ACTIVITIES IN WATERS OF THE U.S. AND WETLANDS

NA

				AQUATIC BIOTA													TERRESTRIAL BIO						
								STANDING WATERS			RUNNING WATERS			BAYS AND ESTUARIES							UPLANDS		
				THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	RESOURCE POTENTIAL	HABITAT QUALITY	COMMUNITY STRUCTURE	FLOW REGIME	HABITAT QUALITY	COMMUNITY STRUCTURE	FRESHWATER DISCHARGE PATTERNS	HABITAT QUALITY	COMMUNITY STRUCTURE	THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
EXPLORATION/MINING	DRILLING	PROSPECT DRILLING	1																				
		WATER WELL DRILLING	2																				
	LAND PREPARATION	DRAINING/DEWATERING	3	-1 -2		-1 -1	+1 +2	-1 -2	-1 -2	-1 -2	-1 -1	-1 -1	-1 -1									-1 -1	-1 -1
		CLEARING	4	-1 -1		-2 -2			-2 -2	-2 -2	-1 -2	-1 -2	-1 -2	-1 -1	-1 -2	-1 -1	-1 -1	-1 -1	-1 -1	-1 -1	-1 -1	-1 -1	-1 -1
		BURNING	5																				
	LAND EXCAVATION	DRAGLINING	6	-1 -1		-1 -1	+1 +1	-1 -1	-1 -1	-1 -1	-1 -1	-1 -1	-1 -1	0 -1			-4 -8	-2 -4	-1 -1	-1 -1	-4 -8	-1 -1	-4 -6
		DREDGING	7																				
		OVERBURDEN PLACEMENT	8																				
		WATER EXTRACTION	9																				
		WATER INJECTION	10																				
		EQUIPMENT RELOCATION	11																				
WASHING/ BENEFICIATION		PRODUCT STORAGE	12																				
		PRODUCT DRYING	13																		-1 -1		
		TAILINGS PLACEMENT	14																				
		SLIME PLACEMENT	15	-2 -4		-2 -4	-1 -2		-2 -4	-2 -4	-1 -2	-2 -4	-2 -4	-1 -2	-2 -4	-2 -4	-1 -1	-1 -1	-1 -1	-1 -1	-1 -1	-1 -1	-1 -1
		WATER USE/RECYCLE	16	0 -1		0 -1	-1 -1	+1 +2			+1 +1	+1 +1	+1 +1	+1 +1	+1 +1	+1 +1							
ASSING	MANUFACTURING	SULFURIC ACID	17			-1 -1			-1 -1	-1 -1		-1 -1	-1 -1		-1 -1	-1 -1						-1 -1	
		FERTILIZER PRODUCTS	18			-1 -1			-1 -1	-1 -1		-1 -1	-1 -1		-1 -1	-1 -1							
		ANIMAL GRADE PHOSPHATE	19			-1 -1			-1 -1	-1 -1		-1 -1	-1 -1		-1 -1	-1 -1							
		ELEMENTAL PHOSPHORUS	20																				

NOLOGICAL DEMAND ELEMENTS

CTIVITIES

B

ENVIRONMENTAL DEMAND ELEMENTS

	NATURAL RESOURCES						PHYSICAL AND HYDROLOGICAL ELEMENTS																		ANXIETY FACTORS							
	ESTRIAL BIOTA																															
	UPLANDS			WETLANDS			LAND						SURFACE WATER		SUBSURFACE WATER				HYDROLOGICAL PROCESSES				ATMOSPHERE									
															WATER TABLE		FLORIDAN AQUIFER															
	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE	MINERAL RESOURCES	UNIQUE PHYSICAL FEATURES	SOILS	EXPOSURE	TOPOGRAPHY	BACKGROUND RADIATION	QUALITY	QUANTITY	QUALITY	QUANTITY	QUALITY	QUANTITY	AQUIFER RECHARGE	EROSION	FLOODING	CAVITATION	CLIMATE/WEATHER	AIR QUALITY	AIR	WATER	RADIATION	NOISE	PERSONAL PROPERTY	UTILITIES	VISUAL DEGRADATION	COHESION
7	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
		-1	-1		-1	-1																										
		-1	-1		0	0																										
1	-1	-1	-1	-1	-1	-1	0						-5																			
1	-1	-1	-1	-1	-1	-1	-1						-5																			
													-5																			
													-5																			
1	-4	-1	-4	-10	-1	-4	-1																									
1	-8	-1	-6	0	-1	0	-3																									
																+1																
																0																
																		-3														
					-1													0														
					-1																											
																								0								
																								-1								
	-1				-1																			0								
	-1				-1																			-1								
-1	-1	-1	-1	-1	-1	-1							-7																			
1	-1	-1	-1	0	0	0							-7																			
																	-1								-1	-1	-1					0
																	-1								-2	-2	-2					-5
		-1			-1													-3														
		-1			-1													0														

ENTRIES IN LINE

IMPACTS FROM L

NTAL DEMAND ELEMENTS

C

				SOCIAL RESOURCES																												
				ANXIETY FACTORS							COMMUNITY							MAN-MADE (OR MAN-ORIENTED)							LAND TENURE		LAND USE					
GICAL SES		ATMOSPHERE																					RECREATION									
	CAVITATION	CLIMATE/WEATHER	AIR QUALITY	AIR	WATER	RADIATION	NOISE	PERSONAL PROPERTY	UTILITIES	VISUAL DEGRADATION	COHESION	SPATIAL GROWTH	DENSITY	DIVERSITY	ACCESSIBILITY OF FACILITIES AND SERVICES	DISPLACEMENT	MOBILITY	TRANSPORTATION	HOUSING	CULTURAL OPPORTUNITIES	AESTHETICS	ARCHEOLOGICAL AND HISTORICAL SITES	WATER BASED	LAND BASED	PUBLIC LAND	PRIVATE LAND	REGIONAL AND COMMUNITY PLANS	RESIDENTIAL DEVELOPMENT	COMMERCIAL DEVELOPMENT	INDUSTRIAL DEVELOPMENT	MINING	FORESTS
8	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
																							-1									
																							-1									
																						-1	-1	-3							+6	-4
																						-3	-3	-5							+10	-8
																						-1	-1								+1	-1
																						-1	-1								+1	-1
																						-10								+1	+6	
																						-10								+3	+10	
																						-1 -3										
																							-1 -1				-1 -1	-1 -1			+1 +3	
																						-1 -1										
			0 -1 0 -1																								-1 -1	-1 -1				
				ENTRIES IN LINE 16 ACCOUNT FOR ALL IMPACTS FROM LINES 1 THROUGH 16																		-1 -3										
				-1 -2	-1 -2	-1 -2					0 -5	0 -5			0 -5	0 -5	-1 -3				-5 -5											
																														+1 +3		
																														+1 +3		-1 -1
																														+1		

D

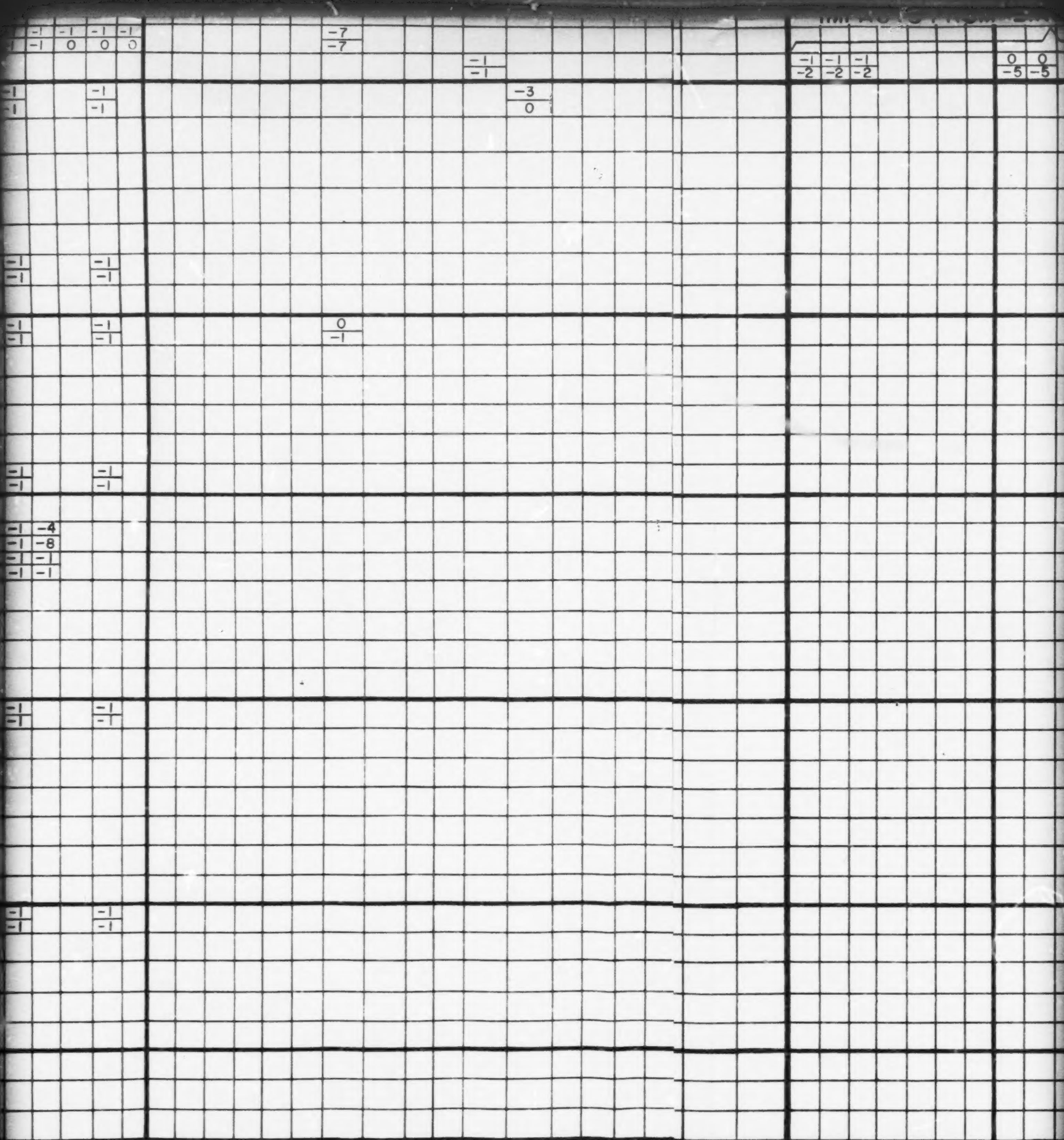
SOURCES – AESTHETICS	(MAN-MADE/MAN-ORIENTED) ARCHEOLOGICAL AND HISTORICAL SITES	RECREATION: WATER BASED	RECREATION: LAND BASED	LAND TENURE: PUBLIC LAND	LAND TENURE: PRIVATE LAND	LAND USE: REGIONAL AND COMMUNITY PLANS	LAND USE: RESIDENTIAL DEVELOPMENT	LAND USE: COMMERCIAL DEVELOPMENT	LAND USE: INDUSTRIAL DEVELOPMENT	LAND USE: MINING	LAND USE: FORESTS	LAND USE: AGRICULTURE	LAND USE: OPEN SPACE	ECONOMIC RESOURCES: NATIONAL ECONOMIC DEVELOPMENT	STATE ECONOMIC DEVELOPMENT	LOCAL: TAX REVENUE	LOCAL: PROPERTY VALUES	PUBLIC FACILITIES AND SERVICES: EDUCATIONAL	HEALTH	FIRE/POLICE PROTECTION	WATER SUPPLY	ELECTRICAL SERVICE	WASTE TREATMENT AND DISPOSAL	STREETS AND ROADS	LOCAL/REGIONAL ACTIVITY: TRENDS IN LOCAL ECONOMIC DEVELOPMENT	TRENDS IN REGIONAL ECONOMIC DEVELOPMENT	EMPLOYMENT/LABOR FORCE	AGRICULTURAL ACTIVITY	BUSINESS AND INDUSTRIAL ACTIVITY – MAJOR ECONOMIC, NON-PHOSPHATE	ECONOMIC GEOLOGIC RESOURCES	BALANCE OF TRADE	NATIONAL DEFENSE OR SELF SUFFICIENCY
59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
		-1/-1																														
	-1/-3	-1/-3	-3/-5							+6/+10	-4/-8	-2/-4	0/-5																			
	-1/-1	-1/-1								+1/+1	-1/-1		-1/-1																			
	-10/-10								+1/+3	+6/+10																						
	-1/-3																															
		-1/-1				-1/-1	-1/-1			+1/+3																						
	-1/-1																															
						-1/-1	-1/-1					-1/-1																				
	-1/-3																															
														0/+5	0/+5	0/+5									0/+5	0/+5	+5/+5	0/+5	+5/+5	-5/-5	+2/+5	0/+5
									+1/+3																							
									+1/+3		-1/-1																					
									+1/+3																							

ENTRIES IN LINE 16 ACCOUNT FOR ALL IMPACTS FROM LINES 1 THROUGH 16

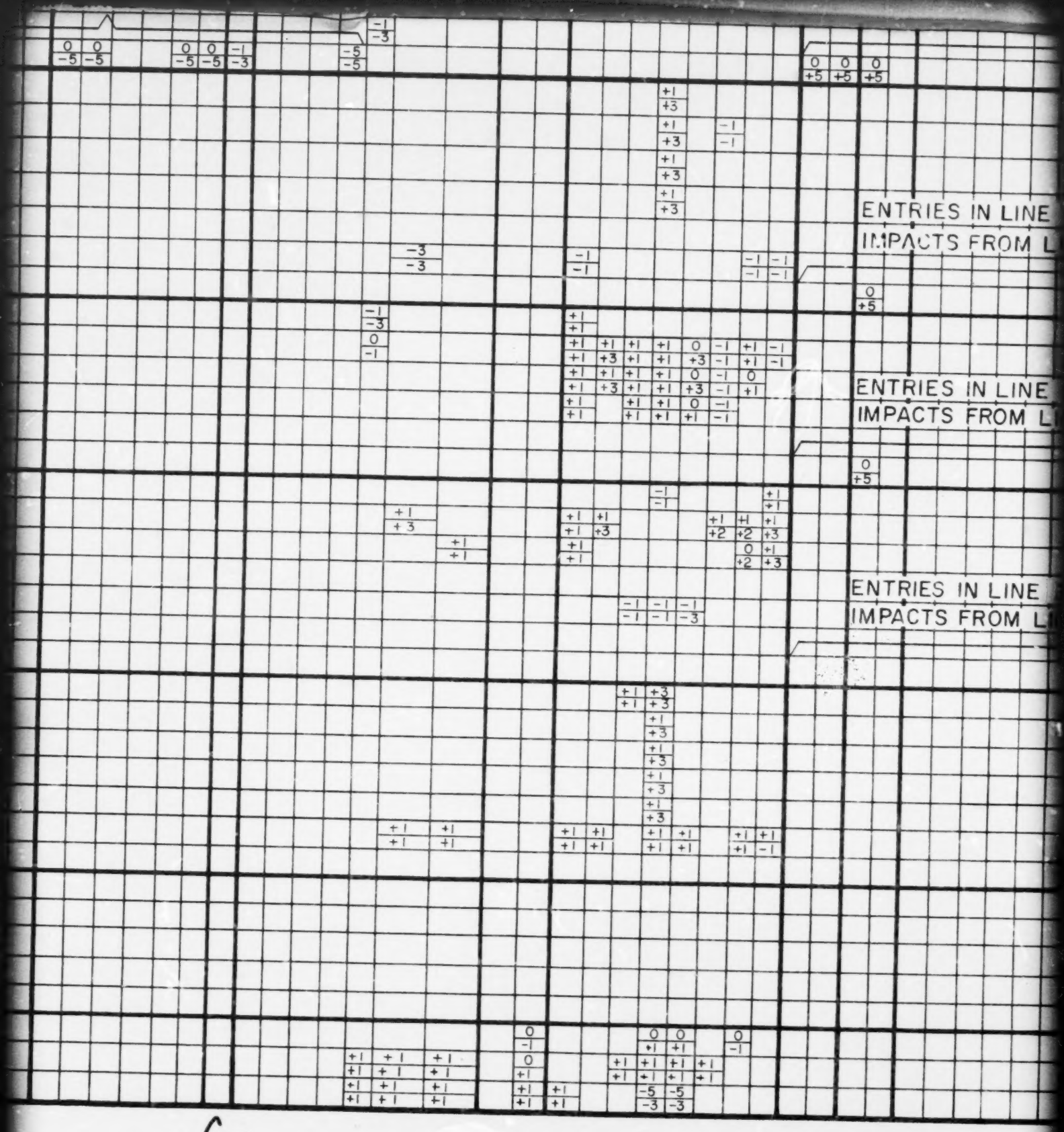
TECHNOLOGICAL DEMAN

PRIMARY ACTIVITIES	WASHI BENEFIC		TAILINGS PLACEMENT	14																				
			SLIME PLACEMENT	15	-2		-2	-1		-2	-2	-1	-2	-2	-1	-2	-2	-1	-1	-1	-1	-1
					-4		-4	-2		-4	-4	-2	-4	-4	-2	-4	-4	-1	-1	-1	-1	-1
			WATER USE/RECYCLE	16	0		0	-1	+1			+1	+1	+1	+1	+1	+1					
					-1		-1	-1	+2			+1	+1	+1	+1	+1	+1					
	PROCESSING	MANUFACTURING	SULFURIC ACID	17			-1			-1	-1		-1	-1		-1	-1					
							-1			-1	-1		-1	-1		-1	-1					
			FERTILIZER PRODUCTS	18			-1			-1	-1		-1	-1		-1	-1					
							-1			-1	-1		-1	-1		-1	-1					
			ANIMAL GRADE PHOSPHATE	19			-1			-1	-1		-1	-1		-1	-1					
							-1			-1	-1		-1	-1		-1	-1					
			ELEMENTAL PHOSPHORUS	20																		
			WASTE TREATMENT	21																		
			WASTE PLACEMENT	22	+1		+1	-1		-1	-1	+1	+1	+1		+2	+2					
					+2		+2	-2		-1	-1	+1	+1	+1		+2	+2					
			WATER USE/RECYCLE	23	+1		+1	-1	+1			+1	+1	+1	+1	+1	+1					
					+1		+1	-2	+2			+1	+1	+1	+1	+1	+1					
	CONSTRUCTION		DAMS AND LEVEES	24	-1		-1	-1	+1	-1	-1	-1	-1	-1	-1	-1	-1					
					-1		-1	-2	+2	-2	-2	-2	-2	-2	-2	-1	-1					
			TRANSPORTATION LINES	25																		
			UTILITY LINES	26																		
			WASHING/BENEFICIATION PLANTS	27																		
			PROCESSING PLANTS	28																		
			DRAINAGE SYSTEMS	29	-1		-1	+1	-1	-1	-1	-1	-1	-1	-1	-1	-1					
					-1		-2	+2	-2	-2	-2	-2	-2	-2	-1	-1	-1					
	RECLAMATION		TRANSPORTATION SYSTEMS	30																		
			MINING PITS	31	+1		+2	-1	+2			-2	-1	-1	-1	-1	-1	-4	-2	-1	-1	-2
					+2		+4	-2	+4			-4	-2	-2	-2	-2	-2	-6	-4	-1	-1	-6
			SLIME PONDS	32	+2		+2	+1		+2	+2	+1	+2	+2	+1	+2	+2	-1	-1	-1	-1	-1
					+4		+4	+2		+4	+4	+2	+4	+4	+2	+4	+4	-1	-1	-1	-1	-1
			UTILITY SYSTEMS	33																		
			PLANT SITES	34																		
			DAMS AND LEVEES	35	+1		+1	+1	-1	+1	+1	+1	+1	+1	+1	+1	+1					
					+1		+1	+2	-2	+2	+2	+2	+2	+2	+2	+1	+1					
			SUPPORT FACILITIES	36																		
	TRANSPORTATION		MINE PRODUCTS	37																		
			WASHING/BENEFICIATION PRODUCTS	38																		
			SULFURIC ACID PLANT PRODUCTS	39																		
			PHOSPHATE PLANT PRODUCTS	40																		
			WATER	41																		
			PEOPLE	42																		
			SUPPORT PRODUCTS	43																		
SECONDARY ACTIVITIES	SUPPORT ACTIVITIES		MINING	44	-1		-1	0				0	0	0	0	-1	-1					
					-2		-2	-1				-2	-1	-1	-2	-2	-2					
			WASHING/BENEFICIATION	45	-1		-1	0				0	0	0	0	-1	-1					
					-2		-2	-1				-2	-1	-1	-2	-2	-2					
			PROCESSING	46	-1		-1	0				0	0	0	0	-1	-1					
					-2		-2	-1				-2	-1	-1	-2	-2	-2					
			RECLAMATION	47																		
			TRANSPORTATION	48			-1									-1	-1					
							-1									-1	-1					
			LAND ACQUISITION	49																		
			RESEARCH AND DEVELOPMENT	50																		
			GOVERNMENT AND PUBLIC RELATIONS	51																		

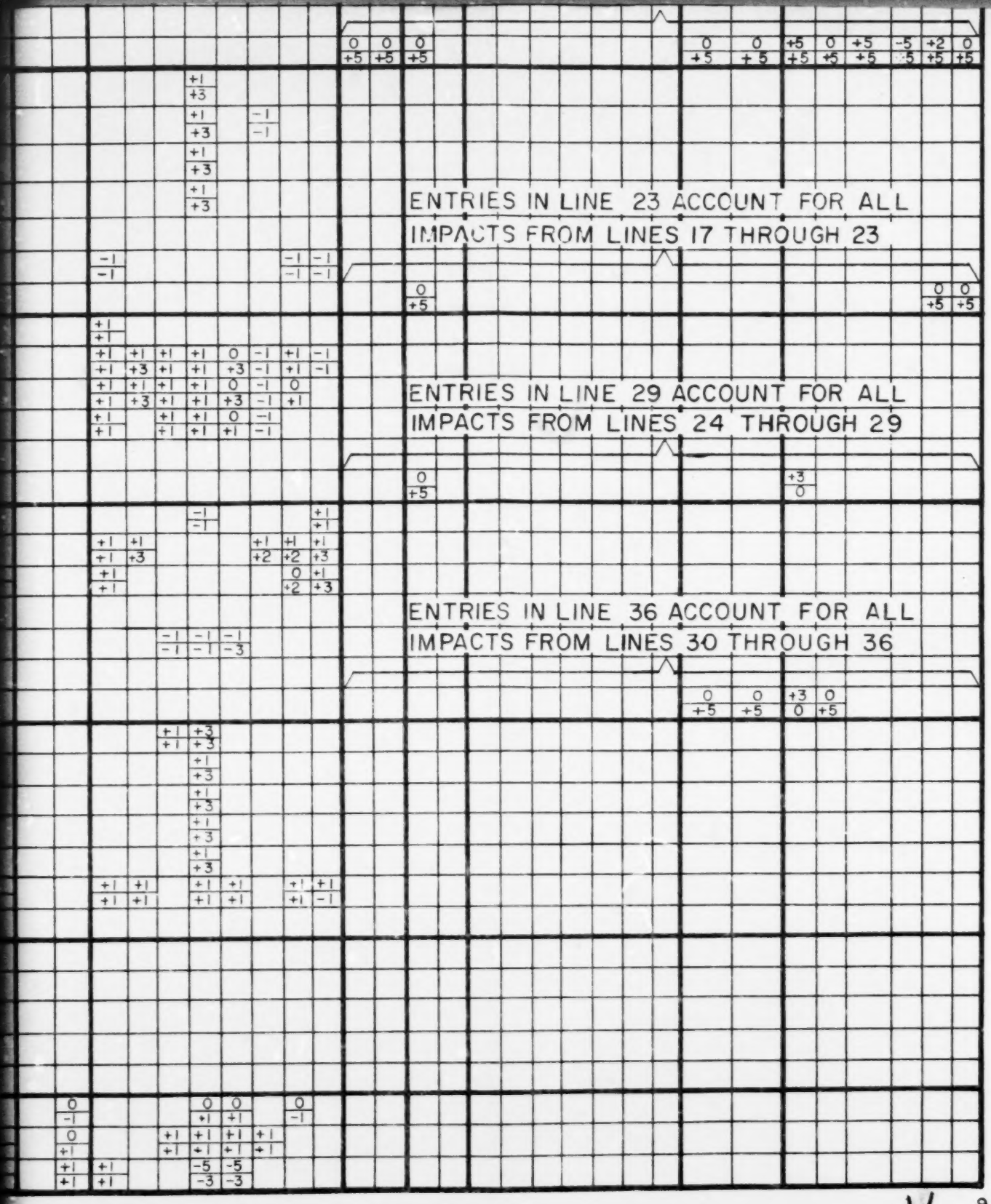
E



F


ENTRIES IN LINE
IMPACTS FROM L
ENTRIES IN LINE
IMPACTS FROM L
ENTRIES IN LINE
IMPACTS FROM L

G


ENTRIES IN LINE 23 ACCOUNT FOR ALL
IMPACTS FROM LINES 17 THROUGH 23
ENTRIES IN LINE 29 ACCOUNT FOR ALL
IMPACTS FROM LINES 24 THROUGH 29
ENTRIES IN LINE 36 ACCOUNT FOR ALL
IMPACTS FROM LINES 30 THROUGH 36

H

A

ENVIRONMENTAL EFFECTS MATRIX FOR CENTRAL FLORIDA PHOSPHATE INDUSTRY

SCENARIO

ASSESSMENT SUMMARY

PLATE 8 - Volume VII

NAT

		AQUATIC BIOTA													TERRESTRIAL BIOT						
						STANDING WATERS			RUNNING WATERS			BAYS AND ESTUARIES							UPLANDS		
		THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	RESOURCE POTENTIAL	HABITAT QUALITY	COMMUNITY STRUCTURE	FLOW REGIME	HABITAT QUALITY	COMMUNITY STRUCTURE	FRESHWATER DISCHARGE PATTERNS	HABITAT QUALITY	COMMUNITY STRUCTURE	THREATENED AND ENDANGERED SPECIES	ECOLOGICALLY SIGNIFICANT SPECIES	COMMERCIAL AND RECREATIONAL SPECIES	NUISANCE AND PEST SPECIES	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GEOMETRIC MEANS OF DECISION WEIGHTS																					
STEERING COMMITTEE		8.9	8.3	8.0	6.2	7.5	8.4	6.7	7.0	8.9	6.9	8.2	8.7	6.9	9.6	8.6	7.8	6.1	9.0	7.9	6.9
ADVISORY COMMITTEE		6.7	6.5	5.7	4.3	5.6	5.8	5.2	7.3	6.4	5.4	7.4	6.7	5.5	6.3	7.2	5.6	4.9	5.3	6.2	4.8
COMBINED		7.8	7.4	6.7	5.3	6.6	7.1	6.0	7.2	7.7	6.2	7.8	7.7	6.2	8.0	7.9	6.7	5.5	7.3	7.1	5.9
ALGEBRAIC SUM OF IMPACT SIGNIFICANCE VALUES RELATIVE TO 2.15 — THE "WITHOUT ACTION" ALTERNATIVE																					
2.11 PERMIT EXISTING AND NEW SOURCES	ST	6		-9	2		-10	-10	-4	-6	-8	0	-6	-6	-11	-9	-5	-5	-10	-12	-12
	LT	-10		-10	-4		-14	-14	-14	-11	-12	-10	-11	-10	-17	-13	-5	-5	-18	-12	-18
2.12 REQUIRE PROCESS MODIFICATIONS	ST	"		"	"		"	"	"	"	"	"	"	"	"	"	"	"	-9	-11	"
	LT																		-18	-11	
2.13 REQUIRE REDUCED WATER USAGE	ST	"		"	"		"	"	"	"	"	"	"	"	"	"	"	"	-10	-12	"
	LT																		-18	-12	
2.14 CONTROL WATERS AND WETLANDS	ST	-4		-8	1	1	-9	-9	-3	-	-7	0	-6	-6	-11	-7	-5	-5	-10	-12	-12
	LT	-6		-9	-5	3	-11	-11	-13	-10	-11	-9	-11	-10	-17	-11	-5	-5	-18	-12	-16
WEIGHTED SCORES-STEERING COMMITTEE																					
2.11	ST	-53		-72	15		-84	-67	-28	-53	-55	0	-52	-41	-106	-77	-39	-31	-90	-95	-9
	LT	-89		-80	-25		-118	-94	-98	-98	-83	-82	-96	-69	-163	-112	-39	-31	-162	-95	-1
2.12	ST	"		"	"		"	"	"	"	"	"	"	"	"	"	"	"	-81	-87	"
	LT																		-162	-87	
2.13	ST	"		"	"		"	"	"	"	"	"	"	"	"	"	"	"	-90	-95	"
	LT																		-162	-95	
2.14	ST	-36		-64	6	8	-76	-60	-21	-45	-48	0	"	"	"	-60	"	"	"	"	"
	LT	-53		-72	-31	23	-92	-74	-91	-59	-76	-74				-95					
ADVISORY COMMITTEE																					
2.11	ST	-40		-51	9		-58	-52	-29	-38	-43	0	-40	-33	-69	-65	-28	-25	-53	-74	-
	LT	-67		-37	-17		-81	-73	-102	-70	-65	-74	-74	-55	-107	-94	-28	-25	-95	-74	

B

ENVIRONMENTAL DEMAND ELEMENTS

NATURAL RESOURCES																																	
BIOTA										PHYSICAL AND HYDROLOGICAL ELEMENTS													ANXIETY FACTORS							COMMU		
ANDS		WETLANDS			LAND						SURFACE WATER		SUBSURFACE WATER				HYDROLOGICAL PROCESSES				ATMOSPHERE											
													WATER TABLE		FLORIDAN AQUIFER																	
HABITAT QUALITY	COMMUNITY STRUCTURE	AREAL EXTENT	HABITAT QUALITY	COMMUNITY STRUCTURE	MINERAL RESOURCES	UNIQUE PHYSICAL FEATURES	SOILS	EXPOSURE	TOPOGRAPHY	BACKGROUND RADIATION	QUALITY	QUANTITY	QUALITY	QUANTITY	QUALITY	QUANTITY	AQUIFER RECHARGE	EROSION	FLOODING	CAVITATION	CLIMATE/WEATHER	AIR QUALITY	AIR	WATER	RADIATION	NOISE	PERSONAL PROPERTY	UTILITIES	VISUAL DEGRADATION	COHESION	SPATIAL GROWTH	DENSITY
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
.9	6.9	7.0	8.0	7.5	7.4	7.7	6.0	5.1	6.8	6.2	8.7	8.3	9.0	9.2	9.7	9.9	9.0	7.1	6.1	3.9	6.0	8.4	7.1	7.4	6.5	5.4	5.4	3.8	6.8	4.7	3.9	5.0
.2	4.8	5.9	6.2	4.3	8.3	6.6	5.9	4.6	4.8	4.6	9.0	8.4	8.4	8.6	8.9	9.8	8.5	5.4	4.7	5.2	3.8	8.0	5.2	7.7	6.1	4.4	6.1	4.2	6.5	4.6	4.4	4.4
.1	5.9	6.4	7.1	6.0	7.9	7.1	6.0	4.8	5.8	5.4	8.9	8.4	8.7	8.9	9.3	9.9	8.7	6.3	5.4	4.6	5.0	8.[illegible]	8.2	7.6	6.3	4.9	5.8	4.0	6.6	4.6	4.2	4.7
-12	-12	-12	-12	-7	-1						-17				-1	-6						0	-1	-1	-1					0	0	
-12	-18	-12	-12	-11	-4						-18				-1	0						-2	-2	-2	-2					-5	-5	
-11	"	"	-10	"	"						1		1		2	"						1	"	"	"					"	"	
-11			-10								1		0		2							0										
-12	"	"	-12	"	"						-14	-10	"		-1	"						0	"	"	"					"	"	
-12			-12								-14	[illegible]			-1							-2										
-12	-12	-1	-10	-1	-1						-17			1								"	"	"	"					"	"	
-12	-18	-1	-10	-1	-4						-18	"	"	0	"	"																
-95	-83	-84	-96	-53	-7						-148			9	-10	-59						0	-7	-7	-7					0	0	
-95	-124	-84	-96	-83	-30						-157			0	-10	0						-17	-14	-15	-13					-24	-20	
-87	"	"	-80	"	"						9		9		19							8										
-87			-80								9		10	"	19	"						0	"	"	"					"	"	
-95	"	"	-96	"	"						-122	-83	9	55	-10							0										
-95			-96								-122	-83	10	0	-10	"						-17	"	"	"					"	"	
		-7	-80	-8							-148			9																		
"	"	-7	-80	-8	"						-157	"	"	0	"	"						"	"	"	"					"	"	
	-58	-71	-74	-30	-8						-153			9	-9	-59						0	-5	-8	-6					0	0	
											-[illegible]				-[illegible]	0						-18	-10	-15	-12					-23	-22	

C

	SOCIAL RESOURCES																								ECONOMIC											
	COMMUNITY						MAN-MADE (OR MAN-ORIENTED)							LAND TENURE		LAND USE											LOCAL		PUBLIC FACILITIES AND SERVICES						
												RECREATION																							
	SPATIAL GROWTH	DENSITY	DIVERSITY	ACCESSIBILITY OF FACILITIES AND SERVICES	DISPLACEMENT	MOBILITY	TRANSPORTATION	HOUSING	CULTURAL OPPORTUNITIES	AESTHETICS	ARCHEOLOGICAL AND HISTORICAL SITES	WATER BASED	LAND BASED	PUBLIC LAND	PRIVATE LAND	REGIONAL AND COMMUNITY PLANS	RESIDENTIAL DEVELOPMENT	COMMERCIAL DEVELOPMENT	INDUSTRIAL DEVELOPMENT	MINING	FORESTS	AGRICULTURE	OPEN SPACE	NATIONAL ECONOMIC DEVELOPMENT	STATE ECONOMIC DEVELOPMENT	TAX REVENUE	PROPERTY VALUES	EDUCATIONAL	HEALTH	FIRE/POLICE PROTECTION	WATER SUPPLY	ELECTRICAL SERVICE	WASTE TREATMENT AND DISPOSAL	STREETS AND ROADS
9	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
	3.9	5.0	4.6	5.8	5.3	3.1	5.7	5.3	6.4	6.1	7.5	7.0	6.4	[illegible]	5.9	7.9	5.0	4.9	5.3	6.7	6.0	7.5	7.1	9.5	6.5	5.2	7.3	5.2	6.6	3.7	7.8	4.0	6.7	4.3
	4.4	4.4	3.9	4.3	4.1	3.6	4.9	5.9	4.0	5.3	6.0	6.7	5.7	[illegible]	4.0	6.6	6.9	6.0	6.4	7.2	6.3	7.3	6.5	5.7	7.2	6.9	7.1	5.2	7.2	4.6	8.5	6.3	6.7	5.1
	4.2	4.7	4.2	5.1	4.7	3.4	5.3	5.6	5.3	5.7	6.7	5.9	6.0	[illegible]	5.0	7.2	6.1	5.5	5.9	7.0	6.2	7.4	6.8	7.7	6.9	6.2	7.2	5.2	6.9	4.2	8.2	5.4	6.7	4.7
	0			0	0	-1				-5	-14	-3	1		1	5	2	4	8	10	-7	-1	-1	0	0	0								
	-5			-5	-5	-3				-5	-23	-3	-1		1	5	8	4	31	26	-10	0	-2	5	5	15								
	"			"	"	"				"	"	"	1		"	6	"	"	"	"	"	-1	"	"	"	"								
													-4			6						2												
	"			"	"	"				"	"	"	1		"	5	"	"	"	"	"	-1	"	"	"	"								
													-1			5						0												
	"			"	"	"				"	-11 -21	"	"		"	"	"	"	"	"	"	"	"	"	"	"								
	0			0	0	-3				-31	-105	-21	6		6	40	10	20	42	67	-42	-8	-7	0	0	0								
4	-20			-29	-27	-9				-31	-173	-21	-6		6	40	40	20	164	174	-60	0	-14	48	33	78								
	"			"	"	"				-31	-105	-21	6		"	47	"	"	"	"	"	-8	"	"	"	"								
										-31	-173	-21	-26			47						16												
	"			"	"	"				-31	-105	-21	6		"	40	"	"	"	"	"	-8	"	"	"	"								
										-31	-173	-21	-6			40						0												
	"			"	"	"				"	-83 -158	"	"		"	"	"	"	"	"	"	"	"	"	"	"								

D

	LAND TENURE		LAND USE								ECONOMIC RESOURCES		LOCAL		PUBLIC FACILITIES AND SERVICES							LOCAL/ REGIONAL ACTIVITY							
ON																													
LAND BASED	PUBLIC LAND	PRIVATE LAND	REGIONAL AND COMMUNITY PLANS	RESIDENTIAL DEVELOPMENT	COMMERCIAL DEVELOPMENT	INDUSTRIAL DEVELOPMENT	MINING	FORESTS	AGRICULTURE	OPEN SPACE	NATIONAL ECONOMIC DEVELOPMENT	STATE ECONOMIC DEVELOPMENT	TAX REVENUE	PROPERTY VALUES	EDUCATIONAL	HEALTH	FIRE/POLICE PROTECTION	WATER SUPPLY	ELECTRICAL SERVICE	WASTE TREATMENT AND DISPOSAL	STREETS AND ROADS	TRENDS IN LOCAL ECONOMIC DEVELOPMENT	TRENDS IN REGIONAL ECONOMIC DEVELOPMENT	EMPLOYMENT/LABOR FORCE	AGRICULTURAL ACTIVITY	BUSINESS AND INDUSTRIAL ACTIVITY — MAJOR ECONOMIC, NON-PHOSPHATE	ECONOMIC GEOLOGIC RESOURCES	BALANCE OF TRADE	NATIONAL DEFENSE OR SELF SUFFICIENCY
2	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
4	5.2	5.9	7.9	5.0	4.9	5.3	6.7	5.0	7.5	7.1	9.5	6.5	5.2	7.3	5.2	6.6	3.7	7.8	4.0	6.7	4.3	5.9	5.7	5.3	6.0	4.9	5.6	4.5	4.1
7	5.9	4.0	6.6	6.9	6.0	6.1	7.2	6.3	7.3	6.5	5.7	7.2	6.9	7.1	5.2	7.2	4.6	8.5	6.3	6.7	5.1	8.0	6.9	7.1	6.8	5.9	6.5	5.8	5.7
0	5.1	5.0	7.2	6.1	5.5	5.9	7.0	6.2	7.4	6.8	7.7	6.9	6.2	7.2	5.2	6.9	4.2	8.2	5.4	6.7	4.7	7.1	6.4	6.3	6.4	5.5	6.1	5.2*	5.0
		1	5	2	4	8	10	-7	-1	-1	0	0	0									0	0	11	0	5	-5	2	0
		1	5	8	4	31	26	-10	0	-2	5	5	15									10	10	5	10	5	-5	10	10
		"	6	"	"	"	"	"	-1	"	"	"	"									"	"	"	"	"	"	"	"
4			6						2																				
		"	5	"	"	"	"	"	-1	"	"	"	"									"	"	"	"	"	"	"	"
			5						0																				
		"	"	"	"	"	"	"	"	"	"	"	"									"	"	"	"	"	"	"	"
6		6	40	10	20	42	67	-42	-8	-7	0	0	0									0	0	58	0	25	-28	9	0
6		6	40	40	20	164	174	-60	0	-14	48	33	78									59	57	27	60	25	-28	45	2
			47						-8																				
26		"	47	"	"	"	"	"	16	"	"	"	"									"	"	"	"	"	"	"	"
			40						-8																				
8		"	40	"	"	"	"	"	0	"	"	"	"									"	"	"	"	"	"	"	"
		"	"	"	"	"	"	"	"	"	"	"	"									"	"	"	"	"	"	"	"
5		4	33	14	24	51	72	-44	-7	-7	0	0	0									0	0	78	0	30	-33	12	0
		4	33	55	24	198	187	-63	0	-13	29	36	104									80	69	36	68	30	-33	58	57

2.13	ST	"		"	"		"	"	"	"	"	"	"	"	"	"	"	"			"	"
	LT																		-162	-95		
2.14	ST	-36		-64	6	8	-76	-60	-21	-45	-48	0				-60						-7
	LT	-53		-72	-31	23	-92	-74	-91	-89	-76	-74	"	"	"	-95	"	"	"	"	"	-7
ADVISORY COMMITTEE																						
2.11	ST	-40		-51	9		-58	-52	-29	-38	-43	0	-40	-33	-69	-65	-28	-25	-53	-74	-58	-71
	LT	-67		-57	-17		-81	-73	-102	-70	-65	-74	-74	-55	-107	-94	-28	-25	-95	-74	-86	-71
2.12	ST	"		"	"		"	"	"	"	"	"	"	"	"	"	"	"	-48	-68	"	"
	LT																		-95	-68		
2.13	ST	"		"	"		"	"	"	"	"	"	"	"	"	"	"	"	-90	-74	"	"
	LT																		-95	-74		
2.14	ST	-27		"	4	6	-52	-47	-22	-32	-38	0	"	"	"	-50	"	"	"	"	"	-6
	LT	-40			-22	17	-64	-57	-95	-64	-59	-67				-79						-6
COMBINED																						
2.11	ST	-47		-60	11		-71	-60	-29	-46	-50	0	-46	-37	-88	-71	-36	-28	-73	-85	-77	-77
	LT	-78		-67	-21		-99	-84	-101	-85	-74	-78	-85	-62	-136	-103	-36	-28	-131	-85	-106	-77
2.12	ST	"		"	"		"	"	"	"	"	"	"	"	"	"	"	"	-66	-78	"	"
	LT																		-131	-78		
2.13	ST	"		"	"		"	"	"	"	"	"	"	"	"	"	"	"	-90	-85	"	"
	LT																		-131	-85		
2.14	ST	-31		-54	5	7	-64	-54	-22	-39	-43	0	"	"	"	-55	"	"	"	"	"	-6
	LT	-47		-60	-27	20	-78	-66	-94	-77	-68	-70				-87						-6

ST = SHORT-TERM TIME FRAME (PRESENT - 1985)

LT = LONG-TERM TIME FRAME (1975 - 2000 AND BEYOND)

E

	"	"	-96	"	"						-122	-83	10	0	-10	"						-17	"	"	"					"	"	
			-96																													
		-7	-80	-8							-148			9																		
	"				"							"	"		"	"						"	"	"	"					"	"	
		-7	-80	-8							-157			0																		
	-58	-71	-74	-30	-8						-153			9	-9	-59						0	-5	-8	-6					0	0	
	-86	-71	-74	-47	-33						-171			0	-9	0						-16	-10	-15	-12					-23	-22	
			-62								9		8		18							8										
	"	"		"	"							"		"		"							"	"	"					"	"	
			-62								9		0		18							0										
			-74								-126	-84		52	-9							0										
	"	"		"	"							"		"		"							"	"	"					"	"	
			-74								-126	-84		0	-9							-16										
		-6	-62	-4							-153			9																		
	"				"							"	"		"	"						"	"	"	"					"	"	
		-6	-62	-4							-171			0																		
	-77	-77	-85	-42	-8						-151			9	-9	-59						0	-5	-8	-6					0	0	
	-106	-77	-85	-66	-32						-160			0	-9	0						-16	-12	-15	-13					-23	-21	
			-71								9		9		18							8										
	"	"		"	"							"		"		"							"	"	"					"	"	
			-71								9		0		18							0										
			-85								-125	-84		53	-9							0										
	"	"		"	"							"		"		"							"	"	"					"	"	
			-85								-125	-84		0	-9							-16										
		-6	-71	-6							-151			9																		
	"				"							"	"		"	"						"	"	"	"					"	"	
		-6	-71	-6							-160			0																		

F

	"	"	"			-31	-173	-21	-6			40						0													"
	"	"	"			"	-83 -158	"	"		"	"	"	"	"	"	"	"	"	"	"	"									"
	0	0	-4			-27	-84	-20	6		4	33	14	24	51	72	-44	-7	-7	0	0	0									0
	-22	-21	-11			-27	-138	-20	-6		4	33	55	24	198	187	-63	0	-13	29	36	104									80
	"	"	"			"	"	"	6 -23		"	40 40	"	"	"	"	"	-7 15	"	"	"	"									"
	"	"	"			"	"	"	6 -6		"	33 33	"	"	"	"	"	-7 0	"	"	"	"									"
	"	"	"			"	-66 -126	"	"		"	"	"	"	"	"	"	"	"	"	"	"									"
	0	0	-3			-29	-94	-20	6		5	36	12	22	47	70	-43	-7	-7	0	0	0									0
	-26	-24	-10			-29	-154	-20	-6		5	36	49	22	183	182	-62	0	-14	39	35	93									71
	"	"	"			"	"	"	6 -24		"	43 43	"	"	"	"	"	-7 15	"	"	"	"									"
	"	"	"			"	"	"	6 -6		"	36 36	"	"	"	"	"	-7 0	"	"	"	"									"
	"	"	"			"	-74 -141	"	"		"	"	"	"	"	"	"	"	"	"	"	"									"

G

"		"	"	"	"	"		"	"	"	"									"	"	"	"	"	"	"	"
	40						0																			
"	"	"	"	"	"	"	"	"	"	"	"									"	"	"	"	"	"	"	"
4	33	14	24	51	72	-44	-7	-7	0	0	0									0	0	78	0	30	-33	12	0
4	33	55	24	198	187	-63	0	-13	29	36	104									80	69	36	68	30	-33	58	57
	40						-7																				
"		"	"	"	"	"		"	"	"	"									"	"	"	"	"	"	"	"
	40						15																				
	33						-7																				
"		"	"	"	"	"		"	"	"	"									"	"	"	"	"	"	"	"
	33						0																				
"	"	"	"	"	"	"	"	"	"	"	"									"	"	"	"	"	"	"	"
5	36	12	22	47	70	-43	-7	-7	0	0	0									0	0	69	0	28	-31	10	0
5	36	49	22	183	182	-62	0	-14	39	35	93									71	64	32	64	28	-31	52	50
	43						-7																				
"		"	"	"	"	"		"	"	"	"									"	"	"	"	"	"	"	"
	43						15																				
	36						-7																				
"		"	"	"	"	"		"	"	"	"									"	"	"	"	"	"	"	"
	36						0																				
"	"	"	"	"	"	"	"	"	"	"	"									"	"	"	"	"	"	"	"

H